P 302

G. R. S. IX-5]

Previous references.

File No. 1 of

191

(Municipal)

Serial Nos. 1

Later references

GENERAL AND REVENUE SECRETARIAT.

Serial Nos.

Major Part B for December 1893.

SUBJECT.

Water supply to Bangalore from Hesaraghatta reservoir.

Inserted
D.R.

W D 88—GPB—50,000—24-7-16

Water Supply of Bangalore

A. Propositions which will readily be accepted.

1. Any satisfactory scheme must provide a sufficient supply not only for present population, but also for the increased population in the near future of a prospering Town. According to the Census of 1891 the population of the Civil and Miliit Station is 1,00,081 and

of the City 80,285. Total 1,80,366. According to the Census of 1881 the population was 1,55,857. The increase of 24,509 in ten years is at the rate of — per mille. We may therefore assume that a proper scheme should provide for a population of say 2,50,000.

2. Seventy gallons per head per day is the quantity reckoned as sufficient in Madras and elsewhere, but in the climate of the Mysore Plateau

a somewhat smaller quantity would be sufficient as is shown by our experience in Mysore City. I would assume that 2 C.ft. per day per head would give an ample supply. The daily supply to be provided would thus be 500,000 C.ft.

3. Lawkeyp Reservoir is wholly insufficient for the supply of Bangalore not even for the City.

Its capacity is as follows:—

	Millions C.ft
Between L. Land & L. Sluices	17.10
Above H. L. Sluice ——	28.61
	45.71
Below L.L sluice not available except by pumping ——	5.50
	51.21.

The catchment area is insufficient and the reservoir never fills even in years of exceptionally heavy rainfall. It is very leaky. It is altogether unsuited for the requirements of Bangalore.

4. Bangalore being on the top of a hill, the idea of pumping it by gravitation must be abandoned. We can only hope

to give a sufficient supply by lifting it. This is not a matter of any great difficulty with modern machinery. People trust their lives to ocean steamers whose safety depends on their engines and large factories have no difficulty in being worked daily by means of steam engines. Why should not a water supply of a growing town be worked efficiently by machinery and without fear of a break down.

Petty sources in the neighbourhood of Bangalore have been investigated and have been found more or less unsatisfactory. For an unfailing supply we must go to some stream partaking as far as possible of a perennial character and build across it a Reservoir capable of containing a three years supply. The nearest such stream is the Arkavati.

6. We have had any amount of discussion on the subject. Now we are no nearer

a solution than we were 30 years ago.

B. The solution I would propose is as follows:—

1. Improve the following tanks in the Arkavati valley.—

Tank	Height above sea level	Independent Catchment area Sq. miles	Catchment area of tanks above. sq. miles	Present Revenue from cultivation Rs.
Kasergatte	2,804	7	224	1,378.
Byata	2,835	7.46	61.49	467.
Kukal	2,834	4.38	144.51	1,540.
Harohalli		.75		
Kukdwanpur		.50.		80.
Total		20.09		3,465.

2. Raise the waste weir of the Kasergatte

15 ft. above its present level and raise the waste-weir of the Kakol and Byata some 6 ft. The quantity of water impounded in these three reservoirs ~~would be as shown below~~: — Wd. give it believed a Suffct Supply — ~~If by the means Suffct for both Cannot be obtained, then our plan will~~

Sept '92

I wrote the above in Sept. but was not able to complete it for want of sufficient information upon certain ~~all~~ points —

If improvement as above of tanks in the

Arkavati Valley cannot be expected to give the supply we want for both Cantonment & City, then our plan will be to restrict our scheme to the City alone, especially as the British Govt have been investigating other schemes for the Cantonment.

~~The quantity required for the City may be assumed as follows:-~~

~~250,000 C ft a day for 3 years = 273 950 000 C ft~~

~~Evaporation say 6 4" per annum = say 126 250 000~~

~~400,000,000 C ft~~

The lift wd. be some 300' and distance to City for which an Iron main wd be reqd. wd. be some 12 miles. The present rate of exchange wd. make the scheme a very expensive one and, ~~I fear that~~ unless both City & Cantonment are combined, the cost, I fear, wd. be prohibitive. In addition to what we have to

Spend upon it, now we must take into account the Value of the lands we propose to utilize & the loss of revenue on lands which have to be thrown out of Cultivation —

Under such circs and with reference to Col. Campbells' observations in the Concluding paras of his note of the 26 Oct I wd like the Scheme to be thoroughly investigated at a Very Early date, separately for the Supply of the City & for that of the Cantonment & Civil Combined City. Mr Caldwell may be entrusted with the preparation of the Preliminary Report, under the guidance of the Civil Engr and if this report is satisfactory the necessary temporary Establishment can at once be entertained for the preparation of the detailed Project —

A Combined Scheme for both City & Cantonment was suggested by the Residency on a previous occasion but for reasons into which I need not enter here we considered that the practical & satisfactory working of such a Scheme wd be attended with numerous difficulties. Those reasons still hold good, and if at all possible I wd prefer a Separate Scheme for the City. Shd this be found a financial impossibility let us then have a Combined Scheme & provide for its Satisfactory working as far as possible by means of proper stipulations to be laid down by the Durbar & Residency

The Cantonment inhabitants are the Maharaja's subjects though now under British jurisdiction, and it wd be only proper that we shd try & provide if possible for their share of the benefits of an assured water Supply.

31 Oct 1892 - Venkatachari Iyer.

MEMO.

WATER-SUPPLY OF BANGALORE.

A. Propositions which will readily be accepted.

(1). Any satisfactory scheme must provide a sufficient supply not only for the present population, but also for the increased population in the near future of a prospering Town. According to the Census of 1891, the population of the Civil and Military Station is 100,081, and of the City, 80,285, Total 180,366. According to the Census of 1881, the population was 155,857. The increase of 24,509 in ten years is at the rate of per mille. We may therefore assume that a proper scheme should provide for a population of, say 250,000.

(2). Twenty gallons per head per day is the quantity reckoned as sufficient, in Madras and elsewhere, but in the climate of the Mysore Plateau a somewhat smaller quantity would be sufficient as is shown by our experience in Mysore City. I would assume that 2 cubic feet per day per head would give an ample supply. The daily supply to be provided would thus be 500,000 cubic feet.

(3). Sankey's Reservoir is wholly insufficient for the supply of Bangalore—not even for the City.

Its capacity is as follows:—

Between L. L. and H. L. Sluices	...	...	17·10	Millions cubic feet.
Do above H. L. Sluice	,,	...	28·61	
			45·71	
Below L. L. Sluice not available except by pumping		...	5 50	
			51·21	

The catchment area is insufficient and the Reservoir never fills even in years of exceptionally heavy rain-fall. It is very leaky. It is altogether unsuited for the requirements of Bangalore.

(4). Bangalore being on the top of a hill, the idea of supplying it by gravitation must be abandoned. We can only hope to give a sufficient supply by lifting it. This is not a matter of any great difficulty with modern machinery. People trust their lives to ocean steamers whose safety depends on their Engines and large factories have no difficulty in being worked daily by means of Steam Engines. Why should not a water-supply of a growing town be worked efficiently by machinery and without fear of a break down?

(5). Petty sources in the neighbourhood of Bangalore have been investigated and have been found more or less unsatisfactory. For an unfailing supply we must go to some stream partaking as far as possible a perennial character and build across it a reservoir capable of containing a three years' supply. The nearest such stream is the Arkavati.

(6). We have had any amount of discussion on the subject. Now we are no nearer a solution than we were 30 years ago.

B. The solution I would propose is as follows :—

(1). Improve the following tanks in the Arkavati valley —

	Height above Sea level.	Independent catchment area.	Catchment area of tanks above	Present Revenue from cultivation.
		Square Miles.	Square Miles.	Rs.
Hessarghatta	2,804	7	224	1,378
Byata	2,835	7·46	61·49	467
Kakol	2,834	4·38	144·51	1,540
Harohalli	.	·75	...	...
Chik Devanpur	...	·50	..	80
		20·09	...	3,465

(2). Raise the waste weir of the Hessarghatta 15 feet above its present level, and raise the waste weir of Kakol and Byata some 6 feet. The quantity of water impounded in these three Reservoirs would give, it is believed, a sufficient supply.

September 1892. K. S.

I wrote the above in September but was not able to complete it for want of sufficient information upon certain points.

If improvement as above of tanks in the Arkavati valley cannot be expected to give the supply we want for both Cantonment and City, then our plan will be to restrict our scheme to the City alone especially as the British Government have been investigating other schemes for the Cantonment.

The lift would be some 300′ and distance to City for which an iron main would be required would be some 12 miles. The present rate of exchange would make the scheme a very expensive one, and, unless both City and Cantonment are combined, the cost, I fear, would be prohibitive. In addition to what we have to spend upon it now we must take into account the value of the tanks we propose to utilize and the loss of revenue on lands which have to be thrown out of cultivation.

Under such circumstances and with reference to Col. Campbell's observations in the concluding paras of his note of the 26th October, I would like the scheme to be thoroughly investigated at a very early date, separately for the supply of the City and for that of the Cantonment and City combined. Mr. Scaldwell may be entrusted with the preparation of the Preliminary report, under the guidance of the Chief Engineer, and if this report is satisfactory, the necessary temporary establishment can at once be entertained for the preparation of the detailed Project.

A combined scheme for both City and Cantonment was suggested by the Residency on a previous occasion, but for reasons into which I need not enter here, we considered that the practical and satisfactory working of such a scheme would be attended with numerous difficulties. These reasons still hold good, and if at all possible I would prefer a separate scheme for the City. Should this be found a financial impossibility, let us then have a combined scheme and provide for its satisfactory working as far as possible by means of proper stipulations to be laid down by the Darbar and Residency.

The Cantonment inhabitants are the Maharaja's subjects though now under British jurisdiction, and it would be only proper that we should try and provide if possible for their share of the benefits of an assured water-supply.

31*st October* 1892.

K. SHESHADRI IYER.

6

MYSORE P. W. DEPT.

—o—

TO THE DEWAN OF MYSORE

for Orders.

—o—

With reference to your Memo: dated 31st October 1892 I forward herewith for submission a report by Mr. Caldwell and one by myself on the project for supplying the Bangalore City as well as the Civil and Military Station and Cantonment with water from Hessarghatta Tank.

As the Scheme is a joint one the report with your remarks will have I suppose to go to the Government of India. I would call attention to the very careful way Mr. Caldwell has

has prepared his report in a short time and in addition to his other duties which are very heavy. —

The Publisher Lt Coll, R.E.,
Secretary to the Govt of Mysore
P. W. Deptt

Bangalore
31st January
1893

on eet on 8 water on B alone

ess tonk No. ——
Nelm ca/

—— : ——

1.— Pe Deuron of Mysore
i, te tetes, o- "e "Oeteik 150°.
(co o- sriei, e exed) coll'e
so, re — i- o- a e, o t
- the p otoced o'ent, o'so ded
os motivo'aiiino, te eove o- e
"o re, "t i'n' é de i,
ontiesda ioe tee te-.
/a /
a.— o'ino o'ceto e'e so
col, 'e 'o, 'e to o- "e tiid
c' a e'tie'o tt ei' 'e'i, s,
o-o 'ett-' 'e' t'i, 50,250.—

— Yotet 150:66. —

3.— 'e e'e' o'i'e'i
1851 'e 'oi'ck o tti i o,
1,88,850 — 'e i o oe' te e
te' o 24,00, ''i' 'o' o t "e
'ote, o- 18"'. 'e ' — c o.—

4.— Ii' ' 'i o ee' c "e e-
ie eot' o 'ero, e, te'— e:
Bto'i- ' ' i' t' 'e
'ode 'c e t — ct
o c i te'i- o- 'c, r- t
'ot 'e ' c te r- " t e ' i
'e oo, o d ' ' — ' , ld
'le o- p 'c ceite ro ' e r
" t o ee, ee '. ——

5.— Gl
i e 'i e e c' r to- ' t e —
'c 'o t — £, o o o', te- o '
C' ' £ e ' 'o ' ' ,
' 'e e' " o ' ' ! , —

and to insure ample storage, the Dewan proposed that the weirs of Hessarghatta tank should be raised 15 feet, and weirs of Swatha and Kakol tanks 6 feet.—

Locality of supply

~~Locality of supply~~:— 6.— The Hessarghatta tank is situated in the Latitude 13°-0' and Longitude 77°-32' vide topographical Survey Sheet No: 42— it is the terminal tank of the Hessarghatta series which consists of 184 tanks and three "Kottans" divided into seven sub series, particulars of which will be found under the heading "Catchment area".—

7.— Swatha tank lies 2½ miles to the North of the village of Hessarghatta, and Kakol tank is situated immediately above the Hessarghatta tank, at a distance of 3½ miles higher up the Arkavathi river across which like the Hessarghatta tank, it is constructed.—

8.— Hasinakunte and Chick Peranthi tanks are very small ones, the former being on the East and the latter on the West of the valley.—

10.— In addition to the five tanks mentioned by the Dewan there are three small tanks, Dyavarakunte, Sambankere and Somnehhulli, the former situated on the East of the valley and

the latter two on the est all of which must necessarily be thrown out of cultivation, as they drain directly into the Hessarghatta tank.—

Present condition of tanks forming storage reservoirs

10. Hessarghatta tank, Dno: 73 Sec. no 187, Nellamangala Taluq: Constructive details are as follows

Waste Weir on left at R.L. 50·00 or M.S.L. 2804·17 and 290 ft
Bund ——— " — 60·00 and top width from ×10 to 57 ft (in length)
Revetment ——— " — 56·00 —
Area of tank ——— " — 50·00 = 1628·795 Square yard
Capacity ——— " — 50·00 = 70·684 Million cft.
Right Sluice ——— " — 28·95 or M.S.L. 2793·12 —
Left ——— " ——— " — ×3·55 or M.S.L. 2797·72 —

× Note: Cross bund on right flank which is only 220 yards in length is the only portion of bund with top width less than 20 ft.—

Bund and revetment in good order:
Right Sluice ——— DO ——:
Left ——— " ——— Somewhat weak ——:
Weir: — Some leaks in left flank of body wall and left wing, and as on requires extensive repair.

11. — Tank is stated to have been nearly dry last year, but [illegible] were cultivated [illegible] at time of inspection (31 Dec 09) the level of water was 65 ft below crest of weir and [illegible] [illegible] at depth [illegible] (1 to 2 ft) for 16 days.—

12. — [illegible]

on the left of the tank will be necessary, and details of work [illegible] proposed to be done are given in statement relating to the cost of the project. —

13. — Gratha tank, Rno: 206, Serial no. 182 Dodballahur Falua

Constructive details are as follows —

Waste weir on right at R.L. 52·00 and 102 ft in length: M.S.L 2835.
— " — left — " — 52·00 and 126 ft in — " —
Bund — " 61·00 and top width 12 ft: —
Revetment — " 57·00 —
Area of tank — " 52·00 — Sq. yards 762,758: —
Capacity at R.L. — " 52·00 — million cft 22,986,963: —
Sluice on left — " 43·88 —
— " — on right — " 47·24 —

14. — Right weir consists of a rough stone apron laid at a slope of 1 in 12 — a pit 6 ft in depth has been scoured out below the apron at a distance of 31 ft from it but as there is a outcrop of rock immediately below the toe of the apron no damage is likely to occur to the weir. —

Left weir — in good order, and consists of a masonry bed wall with [illegible] and a rough [illegible] of [illegible] ft in length, laid at a slope of 1 in 10 — a pit 10 ft in depth has been scoured out in good [illegible] a short distance below the apron but as there is a sheet of rock [illegible] between the apron and pit, the erosion of bed of [illegible] does not endanger the safety of the weir. —

[illegible] is in good order but requires [illegible]. —
Revetments in fair order — Sluices

Shrines in good order. ———

15. [illegible] water on the [illegible] weir, or did not take the [illegible] of [illegible] [illegible] [illegible]

sluices in good order. ——

Weir on left consists of a masonry body wall, and rough stone apron 92 ft in length (laid at a slope of 1 in 6) with masonry toe wall and slab binding walls — the left sluice passes thro' the apron, and tunnel in connection with it forms a masonry binding wall for apron — the weir is in good order, but the ground below the toe wall has been scoured out 4 ft in depth for a distance of 150 ft, and extension of apron throughout this length is necessary, and will be put in hand shortly. ——

19. — Tank was dry last year — at time of inspection (10th Dec/92) water was within 6" of crest of weir and on the 30th of September, there was 3 ft of water passing over the discharge over the weir during current year, varied from ~~2~~ inch to ~~3 feet~~ in depth for 33 days. ——

20. — The undermentioned work will be necessary in connection with raising the water level 6 ft. Construction of a body wall in front of the weir, with slabbed overfall. ——

Raising the bund to R.L. 67.00 and revetment to the same height. —

The construction of new body wall will be very costly, as the bed of tank on right flank, where

where it must be constructed, is 5 ft below the crest of present weir which there is not I think any alternative, as even if a new weir was constructed on the high ground to the left of the present cord, the apron would have to be carried down to the level of toe of present apron, and construction of such a weir would prove much more expensive than that of a body wall in front of present weir. ——

21. In connection with the raising of weir level of this tank, I would beg to bring to notice that a from the plans showing the [illegible] executed in connection with the restoration of [illegible] 19[illegible], it would appear that the [illegible] body breaches in [illegible] placed and it is to be [illegible] that [illegible] the weir [illegible], in order to [illegible] it has already been raised, will be sibly more disastrous. ——

22. [illegible] Tro: 211 Serial no. 26, Road [illegible]

— [illegible] —

Weir on right of [illegible] 50·00 [illegible] 50 ft [illegible] —
Bund aft —— " —— 54·50 with [illegible]
Revetment —— " —— 54·00 ——
Sluice —— " —— 43·50 ——
Area of tank —— " —— 50·00 —— [illegible]
Capacity of tank —— " —— 50·00 —— [illegible] 3·113 -
Bund and revetment in good order. ---
Sluice leaks. ---
Weir consists of only a rough toe [illegible] which should be extended 20 ft, [illegible] as cut back to [illegible] of [illegible]

[illegible] stored during the year
[illegible] only sufficed for cultivation

2e. — Chick Devanhur tank, R.No. 210, Serial no. 183, Dodballapur Taluk

— Constructive details —

Weir on right at R.L. 50.00 and 36 ft in length —
Bund at R.L. 54.50 with top width of 4½ ft —
Revetment — " — 54.00 —
Sluice — " — 46.31 —
Area of tank at R.L. 50.00 — = 81,621 sq yards. —
Capacity — at — " 50.00 — = 2,000 million cft —
Bunds in good order —
Revetment bulged somewhat in places, but in fair order —
Sluice leaks and requires repair —
Weir — Consists of a few rough stone laid as an apron, a masonry body wall 36 ft in length, [illegible] stone at or 12 ft in width wanted. —
Tank dry at [illegible] of inspection, all [illegible] stored having been used for cultivation —

24 — [illegible] tank, R.No. 41, Serial no. 186, Nellaragla Taluk. —

— Constructive detail. —

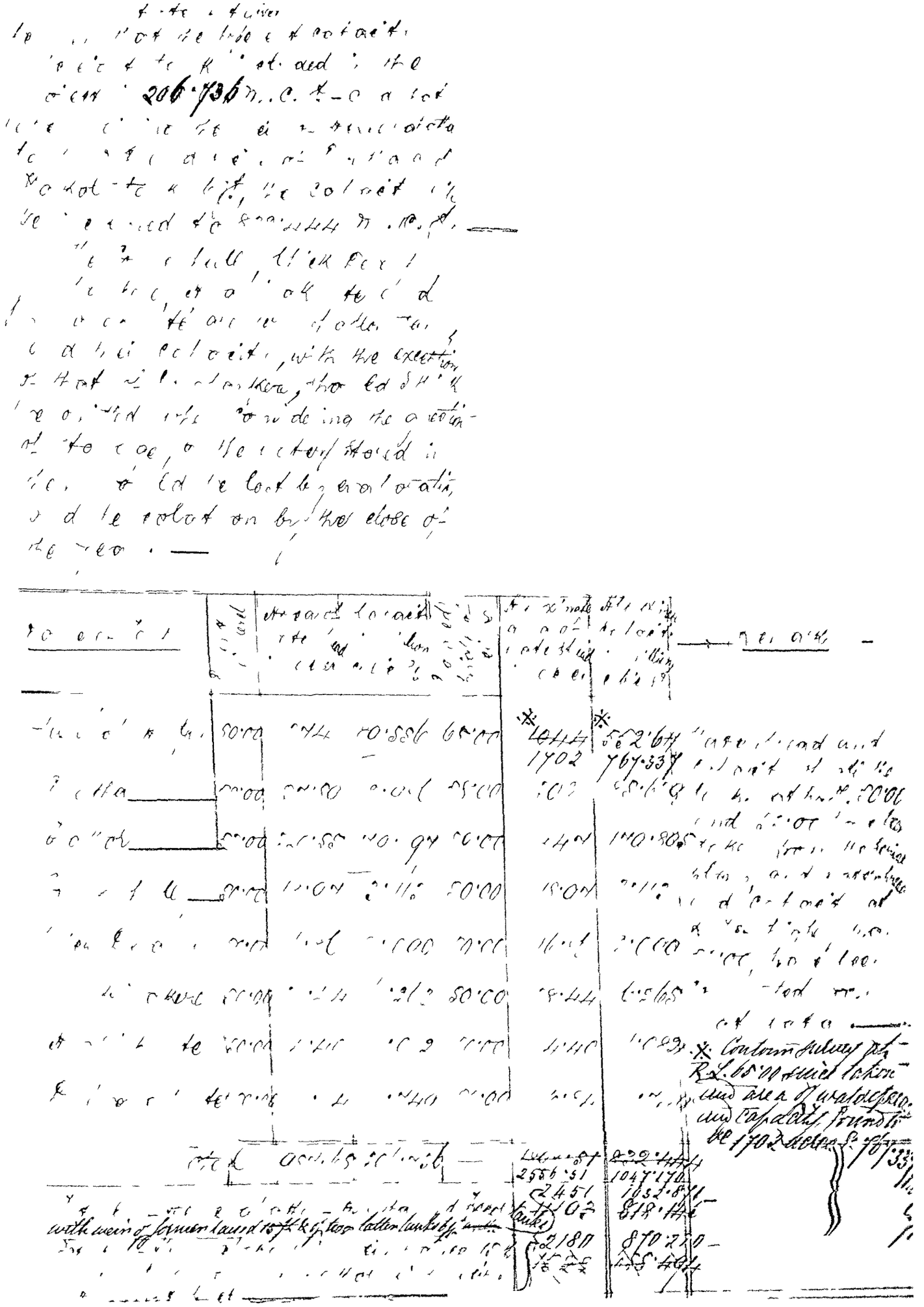
Weir [illegible] at R.L. 50.00 and 101 ft in length. —
Bund — at — " — 54.50, and top width 4½ ft. —
Revetment — " — 53.00 —
Sluice — " — 42.55 —
Area of tank at R.L. 50.00 — = 186,088 sq yds —
Capacity — at — " — 50.00 — = 6.265 million cft —
Bund ~~[illegible]~~ revetment and sluice in good order —
Weir — Consists of masonry body and toe walls with rough stone at or 24 ft in width. —
Ground below the weir scoured out to a depth of [illegible] ft, by a

—: Constructive details: —

Weir at R.L. 50·00, and 25 ft in length —
Bund " — " — 54·50 with top width of 4½ ft. —
Reservoir — { None, the front slope having been made 3 to 1 and turfed }
Sluice at R.L. — 46·00 —
Area of tank at " — 50·00 — = 81,544 sq. ft.
Capacity — at " — 50·00 — = 1·749 million cft.
Bund & front slope eroded — at the level, owing to neglect of [illegible] of turfing. —
Sluice in good order —
Weir is a natural one and no work is needed to it. —
[illegible], the water stored [illegible] sufficient [illegible] the cultivation, notwithstanding half of the cultivable area below the tank has been taken [illegible] in plantations —
27. — The [illegible] stated [illegible] the [illegible] value [illegible] the right [illegible] the [illegible], [illegible] stand. —

Specification of value of Engine Tanks Engineering Department

Serial No	Regd. No	Name of Tank	Storage Capacity in Gallons	Dead Stock	Tank Room wein	Total	Distribution Tons	Stores	Spirit Tanks	Total	Estimated Expenditure in connection with Tanks Buildings &c	Rands
1	205	Diamond Tank	1000	391	"	1400	"	"	"	1400	624	2024
2	204	Left side Tank	838	281	94	1233	160	160	"	1393	563	1956
124	200	Dakota	1172	4471	2089	19180	727	72	61	1997	1808	38059
126	211	Standard Tank	1067	834	136	2034	244	44	"	227	346	2624
182	206	Portable Tank	6687	228	170	10682	190	109	"	1088	1952	12833
183	210	Block Reservoir	1107	803		1910	202	202	"	2112	237	2349
186	71	Fixed Tank	162	759	618	3005	302	302	"	330	941	4424
1[illegible]	73	Reserve Tank	1476	1044	1014	26223	1239	1239	"	2746	15241	40170



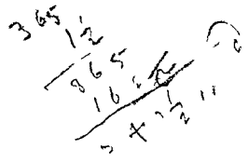
~~Quantity of water to be stored~~

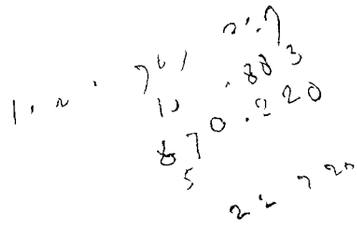
water to be stored

29.— To store a supply of water for 3 years, at the rate of 500,000 cft per day, a reservoir of capacity of 547.500 M. C. ft is required — and as the Hessarghatta tank alone with weir raised 15 ft will store ~~5.11~~ 219.837 M. C. ft, and with Jathna and Kakol tanks at present weir level ~~106.883~~ 322.720 M. C. ft, in excess of this quantity, I would submit that storage reservoir should be restricted to Hessarghatta tank with weir raised 15 ft, and Jathna and Kakol tanks at present weir level. —

365
1½
365
16 2/4
5 + 1½ "

1 . 761 . 217
10 . 883
870 . 220
5
22 . 720





Grounds for recommending restriction of storage reservoir

~~Grounds for recommending restriction of storage reservoir~~

30.— [illegible] reservoir, [illegible] years, there will be a [illegible] of 5 [illegible], [illegible] the tail water of the [illegible] tanks above which will replenish [illegible] and lost by evaporation for some time, [illegible] probably keep the tanks full [illegible] of [illegible]. —

[illegible] of the [illegible] Jathna and Kakol tanks [illegible] the [illegible] at [illegible] and [illegible] together with the cost of [illegible] [illegible] would be [illegible] extended [illegible] for land [illegible] of cultivation [illegible] be restored [illegible]

xx Former [illegible] made with regard to land revenue [illegible] are believed to be [illegible]

[illegible] of [illegible] of weir of Bradfield tanks 6ft; he [illegible] considered unadvisable, [illegible] author [illegible] at [illegible] of this report.

19. ~~Evaporation and percolation~~ — Percolation and evaporation.

21. — The [illegible] Bradfield [illegible] [illegible] and [illegible] and [illegible] [illegible] little [illegible] [illegible].

The Bradfield tanks consist of clay [illegible] and on both banks of [illegible] [illegible] with [illegible] [illegible] which [illegible] at a depth of 8ft below [illegible] [illegible], ~~consequently~~ if excavation of [illegible] within the [illegible] of the [illegible] [illegible] [illegible]

Contour	Area in acres at Contour	Capacity in M cft at contour	Capacity in units at contour	— Remarks —
50·00	374	89·817	344	
53·00	508 ~~508~~ ~~639~~	148·303 ~~148·303~~ ~~155·091~~	558 ~~568~~ ~~595~~	Area and capacity at the several contours are based on area and capacity at 50·00 & 65·00 as actually surveyed.
56·00	~~642~~ 905	~~223·368~~ 256·658	~~855½~~ 983	
59·00	~~776~~ 1171	~~315·927~~ 392·428	~~1210~~ 1503	
62·00	~~910~~ 1436	~~425·979~~ 562·402	~~1631½~~ 2154	
65·00	~~1044~~ 1702	~~552·611~~ 767·337	~~2120~~ 2939	

Percolation at 15 p.c. of capacity of reservoir 115·098 ~~87·891~~ m.cft

Annual consumption at 500,000 cft per day 182 500 "

X Evaporation allowing 6 ft in depth per annum 340·209 ~~202·611~~

Total — 637·807 ~~473·002~~

Total capacity of reservoir 767·337 ~~552·611~~

Balance — ~~79·609~~ 129·530

※ Add quantit stored in the other seven tanks 116·125

Water available in reservoir at end of first year under conditions stated in para 32 . . . . 245·655 ~~195·734~~ m.cft

X Evaporation has been calculated at 6 ft in depth on the mean area between 56·00 & 65·00

※ No deduction on account of percolat evaporation has been made from storage of other tanks, as the percolation would find its way into the Hasserghatta tank and the evaporation would be very little, a

would be run out of the tanks immediately the level of water in the Hesserghatta tank fell below the weir.

33 In the above calculations no allowance has been made for the tail water from cultivation and percolation from tanks situated above the Hesserghatta tank, which is undoubtedly a large quantity, as notwithstanding 65 M.C.ft of water (over $\frac{2}{3}$ rds of capacity of tank) is used annually for cultivation, yet the tank is generally half full at the end of the season during years of ordinary rainfall.

Catchment area.

Extent 34 The total catchment area of the Hesserghatta tank and the 183 tanks situated above it is 211.78 Sqr miles (vide statement B) of which the catchment area 22.78 Sqr miles — see statement A — of Hesserghatta, Byatha, Kalk and the five minor tanks, comprised in the project is free.

35 In addition to the above free drainage area, the catchment area, 8.85 sqr miles, of the 12

(Page 9)

Catchment area –

12 tanks situated in the vicinity of the Hessergpatta tank (noted statement C) is really free to the extent of $\frac{2}{3}$ rds of the run off during average years and $\frac{1}{2}$ during 2 years of minimum rainfall, the tanks situated within that area being so small compared with the catchment, that not more than $\frac{1}{3}$ of the run off during ordinary years, can be in [illegible].

~~extent~~ 36 With reference to ~~this~~ run off from other tanks I would here mention that the whole of the Kolathur sub series is similar in this respect, the catchment [illegible] being 38.52 sq. miles, from which, a run-off of 269.64 in cft (1032 units) could be anticipated during a year of scanty rainfall, while the capacity of the 39 tanks comprised in the sub series is only 471 units — [illegible] however are very much scattered, and at a long distance from Hessergpatta [illegible] has been considered [illegible] to deal with the [illegible] from Kolathur [illegible] the same [illegible]

37 A further free catchment area of 3·21 sqs. miles might be obtained by throwing out of ~~cult~~ cultivation the wet land below the four tanks mentioned in statement D, and if project is carried out I would strongly recommend this being done, as the free catchment area mentioned in paras 34 & 35, is insufficient during years of minimum rainfall, when no surplus is available from the numerous tanks above.

38 With reference to the surplus from tanks situated above the tanks comprised in the project, the statement marked B. annexed shows pretty clearly that 853·785 M.C.ft could be anticipated during ordinary years, while during seasons of drought the supply would hardly equal the capacity of the several tanks.

39 From the foregoing it will be seen that the free catchment area, providing the four tanks noted in statement D are thro

thrown out of action amounts to 25·99 sqr. miles to which dur years of minimum rainfall, the catchment area 4·41 sqr. miles of the twelve tanks shown in the statement marked C should be added — this gives a free gathering ground of 30·4 sqr. miles during the worst years, which are really the only ones that need be con=sidered with reference to the pro=ject, as during ordinary years the surplus from tanks above would be much more than sufficient to fill the whole of the tanks comprised in the project.

assessment etc o ei tanks rising

per Assess=ment	Area under revenue wet land	Reve=nue		Reve=nue	ion and 1 J	2 Reve=nue	Average revenue rea=lized during past 10 years	Remarks.
1862-0-0	202-2	1216-"	110-19	628	313-6	×1844-4-0	1095-11-8	× Actual amount realized was only Rs 1344-9-0.
1534	75-18	492-12-"	10-17	77-8-"	×85-35	570-4-0	612-4-10	× not ¼ cultivated.
2298-	123-33	791-8-"	11-10	50-12-"	×135-3	842-4-0	963-4-10	× little over ⅓rd cultivated
2	44-9	220-"	1-3	15-1	46-25	235-0-0	152-0-0	
192-0	27-	142-"-"	2-13	19-1	30-1	162-0-0	92-0-0	
"	"	"	"		"	"	"	
124-	25-6	12-"-"	6-	12-"-	31-30	124-0-0	60-0-0	
85	19-	82-"-"	1-2	3-"-1	21-18	84-0-0	47-0-0	
					X	X		
6361					563-3	3861		

tivable land below the eight tanks is occupied and the calculation cultivation by submersion &c has been restricted to the actual mainder of the land is valuable as pasturage, and would ate for cultivation of other than wet crops, and loss of revenue probable cost of project.

Statement B showing capacity and catchment

Name of sub series	number of tanks in sub series	Serial numbers of tanks in sub series	Capacity mcft
Byatha	55	1 to 2 & 135 to 187	2374.1
Kolathur	39	36 to 41	471
Nagankere	35	47 to 81	1045.8
Jumberkere	16	84 to 99	605.2
Arlamalligay	25	100 to 124	1074.4
Kakol	10	125 to 134	228.3
6 Minor tanks	4	42.45-46.83	68.3
Total —	184	"	5,867.1
Deduct catchment and capacity &c. of eight tanks included in project (vide statement —			791.7
Balance) —			5075.4

Allowing 7 mcft per Sqs. mile as minimum run-off the
which would hardly fill the tanks the capacity of
With an average run-off of 11 mcft per Sqs. mile the tan
would be 3
With a maximum run-off of 17 mcft per Sqs. mile
which is upwards of three times the capacity

all in the ... ratta series —

Catchment area of tanks in acres	Cult below tanks	~~Libration~~ of sub series with rence to the Hes=tta tank	— Remarks —
46,229	4,535	orth West	
24,651	1326	orth East	In this sub series the run off from the catchment of 3852 sq. miles would be 269·64 m cft (1032 during a year of minimum rainfall; so that even during a bad year more than half the catchment may be consi= free.
23,494	2,749	Do	
13,398	1,283	Do	
17,775	1975	North West	
6,490	530	North East	
3,4[illegible]	27		
13553	1265		
14,582	1,115		
820,52 or 1 miles	11,50		

upply from 189 sq. miles would be 1296 m cft or 4963 units
hich is 5075 units
supply would be 2179 m cft or 8345 units, and surplus
0 units or 853·785 m cft.
surplus would be 7130 units or 1,861·618 m cft
the whole of the eight tanks comprising the profit.

Statement A

(Page 11)

Serial No.	Names of tank	area in acres.	Present capacity in units	Cultivable area & Revenue wet land	Assessment			
187	Aesserghatta	4,405	344	211-23	1233-12-0	110-19	628- -	
182	Byatha	4,954	88	27.22	1486-0-0	5 35	48--	233
134	Kakol	2,553	305	51-22	2244-8-	12-9	53-8--	363
136	Sonnenhulli	401	12	50-13	251	1-36	15-0-0	5
183	Chick Devanpur	463	8	32-27	173-	2-13	19-	3
186	Jumbunkere	990	24	"	"	"	"	
1	Dyavara Kunte	318	6.7	25-6	112-	6-24	12-0-0	31-
2	Arasinakunte	498	4	19-29	82-	1-29	3-0-0	21
	~~Maduray amane tank~~							

Total — 14582 or 791.7 or
22.48 Sq. miles 206.736 mc

From this statement it appears that only 10th/16 of the p
of compensation payable for land thrown
area on which assessment is now paid — the
be gladly taken up by ryots at a reduced
on this score has been included in abstract

Statement C of tanks draining into the Kakol and Byatha tanks the catchment area of which is practically free to the extent of $\frac{2}{3}$rds of the run off during years of average rainfall and during years of minimum rainfall.

Serial No.	Register No.	Name of tank	Taluq	catchment area in acres	capacity of tank in mcft	Cultivable area	Remarks
			— North of Byatha tank —				
137	209	[illegible]undra	Dodballapur	899	8,113,041	79	Capacity of tank only sufficient for cultivation of 32 acres as a vyshake op
181	310	Kodihulli	"	407	5,334,768	45	— Do — 20 — Do
180	317	Kallodakere	"	300	2,999,160	30	— Do — 12 — Do
179	318	Kallodaane	"	300	1,290,249	11	— Do — 5 — Do
	46	Iyankutta	"	381	"	17	
8	47	Matta Gowdanakere	"	281	2,683,233	22	— Do — 10 — Do
			— North of Jambenkere tank —				
184	319	Maistry Pallya	Dodballapur	253	288,468	3	
	70	Elchalahulli	Nellamangala	380	769,419	23	— Do — 3 — Do
			North of Sonnenhulli				
135	213	Carlapura Pallya	Dodballapur	652	3,047,031	27	— Do — 12 — Do
			— North of Kokol tank —				
131	214	Nellikere	Dodballapur	402	1,613,709	8.8	Do — 6 — Do
	234	Chellahalli Pallya	"	516	3,632,904	62.8	Capacity of tank only sufficient for cultivation of 14 acres as vishake
		Aigenane Harrow	"	896	3,979,393	77.2	— Do — 15 — Do
		Total		5,667 or 8.85 sq. miles	33,751,375 or 129.26 units	405.8 acre	

Statement D - Tanks which might be taken up to increase the catchment area.—

Serial No.	Register No.	Taluq	Name of tank	Catchment area in acres	Capacity of tank in Mcft	Cultivable area below tank	Remarks.
				Rs of	Lot		
3	172	Dodballapur	Shanbogunhulli	490	960,120	28	
4	227	"	Bandamarnhulli	656	2,893,995	32	
6	225	"	Bandamarnhulli arrikere	315	405,566	39	
7	199	"	Yallikere	594	8,680,851	70	
			Total —	2055 or 3·21 Sq. miles	16,586,532 or 6352 units	169	

13)

Run off from Catchment

40 For the Rachenhulli project Mr. W. De Winton has allowed 13 per cent run-off during a good year, which is equivalent to 20908 mcft per sqr. mile from a rainfall of 36"

Major S. Grant R.E. assumes that the field from the Maligal catchment would be 13 per cent for a very bad year with a rainfall of 17" — 25 per cent for a mean year with a rainfall of 36", and 40 per cent for a very good year with rainfall of 56" — the run off per sqr. mile based on these assumptions would be 5 134 - 20.908 & 52 039 mcft

41 The records of the Bangalore water supply reservoir show that the actual run-off per sqr. mile has been as follows —

Minimum 7 mcft [illegible] 11 mcft and [illegible] during the current [illegible] which, notwithstanding the [illegible] rainfall [illegible] 2[illegible]3, is admitted to have been [illegible] one, the run off [illegible] per sqr. mile = 18.3 per cent

42 Of the catchment [illegible]

miles, mentioned in
the 3·12 sqr. miles,
waterspread of tanks
sqr. miles comprising land
thrown out of cultivation
the Bayatha, Kakol and five
other minor tanks, will yield
a run-off much greater than
that from the catchment area
of the Bangalore Water supply
Reser[illegible] and considering that
the remainder of the catchment
area, consisting of dry cultiva
tion, will be very impervious
when the tank filling rainfall
in September, it may be accepted
that the catchment area in question
is similar to that of the Bangalore
Water Supply Reservoir –

— Rain fall —

43 A statement comparing the rainfall
at Nellamangala, Dodballapur,
and Yellahunka stations, in the
vicinity of the catchment of the
Hesserghatta series, with that on
the Water Supply catchment area
during the past three years is
appended, but with reference to
the same I would here mention
that the records of the three stations
are incomplete, and I consider
untrustworthy —

44 From my knowledge, which
extends

	November	5·94	"×	4·20	4·30
	December	·24	·46	·25	·43
		·26	·30	·25	"
	Total —	19·78	6·72	10·22	12·45
892	January	"	"	"	"
"	February	"	"	"	"
"	March	"	"	"	·18
"	April	1·39	·98	1·15	1·84
"	May	4·8	5·39	2·90	1·71
"	June	3·95	6·70	9·32	4·24
"	July	3·66	3·31	2·32	1·63
"	August	8·32	7·11	×	9·32
"	September	2·83	2·89	5·56	1·75
"	October	2·51	2·10	1·58	2·81
"	November	·29	·90	·83	"
"	December				
	Total	27·03	29·38	23·60	23·48

yield from catchment 25·898 mcft = 11 598 mcft per square mile

2nd December 1892

× In places marked thus the returns have not been received

Statement of rainfall during 1890, 18 1 & 1892 on catchment area of Hesse ghutta [illegible]
Bangalore water supply reservoir

Year	Month	Rainfall in inches and cents				Remarks
		Sankey's reservoir	Nellamangala	Dodballapur	Yellahunka	
"	January	"	"	"	"	
"	February	"	"	"	"	
"	March	·76	"	"	"	
"	April	3·57	2·21	"	2·53	
"	May	4·67	3·38	x	x	
"	June	1·5	x	10	x	
"	July	4 02	2 22	1·92	1·94	
"	August	6·95	6·16	"	3 33	
"	September	3·70	3·37	1 92	4·02	
"	October	3·81	"	4·98	8·65	
"	November	5 66	2 39	7·42	6·38	
"	December	"	"	"	"	
	Total	34·29	19·73	16 34	26·85	
18 1	January	"	"	"	"	
	February	"	"	"	"	
	March	·69	"	"	"	
	April	·28	"	"	·70	
	May	"	"	"	"	
	June	6·94	5·96	7·67	4·76	
		2·45	"	" x	·85	

15
14)

extends over several years, of the country forming the gathering ground of the whole of the series, I think I may safely state the rainfall at Hesserghatta is similar to that at Bangalore while in the vicinity of Mandi=droog it is greater — allowing this, also that the catchment area is similar to that of the Banga=lore Water supply reservoir, it follows that the yield mentioned in para 30, may be taken as the basis for calculation of 2 annual supply

Yield anticipated from catchment

During ordinary years the supply from the catchment area would be 334·4 mcft which would ~~a little more than~~ just half fill the impounding tanks, but this is immaterial, as the surplus alone from tanks above in addition to this quantity would supply ~~199·346~~ 303·668 mcft more than the tanks will store

46 The supply during year of mi=nimum rainfall of 17" would be 212·8 mcft and in the event of this occurring during the first year the supply of the station [illegible] the result would be, that [illegible] x 240·605 plus 212·80 mcft = ~~408·531~~ 458·4[illegible]

(vide para 32

would be stored for use during the following year, and level of water in the Hesserghatta tank would be 60·00—

Allowing a minimum rain-fall of 17" during the second year there would be ~~179·504~~ mcft stored for use at commencement of third year, as per details below.—

Quantity in reservoir at end of first year ~~408·534~~ 458 455 mcft

Percolation 15 per cent of quantity stored — ~~61·280~~ 68·768 m

Annual consumption at 500,00 cft per day — 182·500—

Evaporation, allowing 6 ft in depth per annum from mean area $\frac{1879 + 629}{2}$ acres = ~~198·05~~ 247·78

Total — ~~441·83~~ 499·04

Balance minus — ~~33·29~~ 40·593

Add the yield for the year 212 80

Balance available at end of second year — ~~179·504~~ 172·207 mcft

47 The annexed statement marked E shows the actual surplus from the Byatha & Kakol tanks and quantity lost by discharge over weir of Hesserghatta tank during the current year.—

48

Sanitary condition of Catchment area.—

There are eight villages, particulars of which, with regard to population &c, are given below, situated in the vicinity of the margin of Hesserghatta tank, and draining direct into it, and in addition to these there are the villages of Byatha and Kakola, draining directly into the tanks of the same name.

West of Arkavathy valley.	Sonnenhulli	115 houses &	415 inhabitants
Villages, draining directly into Hesserghatta tank.	Chickdevanpur	—	—
	Baswanpur	57	246
	Ramsundra Pollia	—	—
	Kodinaikenhulli (Jodi village)	17	100
East of valley —	Harohully	42	152
	Dasserhully	"	"
	Goondhully	82	234
	Total	269 ~~157~~	~~576~~ 1141

Statement E 2h.

(Page 17)

Ore. weir d

Month	date	Hakol tank weir 202 ft depth of discharge	Quantity in cft per minute	Total for 24 hours	B d
— July —	4"	1½"	1997.04	28,756,737.6	
	5"	4"	8,734.4	12,577,536	
	6"	8"	24698	35,565,120	
	7"	6"	16048	23,109,696	
	8"	3"	5,677.3	8,175,398.4	
	9"	2"	3088.8	4,447,929.6	
	10"	1"	1091.8	1,572,192	
— August —	16"	6"	16048.4	23109696	
	17	1"	1091.8	1572192	
	18"	½	386.5	556,525.4	
	19"	½"	386.5	556525.4	
	20"	7"	20,220.5	29117666.4	
	21st	7"	202205	29117666.4	
	22nd	1"	1091.8	1572192	
	23rd	½	386.5	556525.4	
	24th	½	386.5	556525.4	
	25"	4½"	10415.5	14,998,406.4	
	26"	4½"	10415.5	14998406.4	
	27"	3"	5677.3	8175398.4	
	28"	1½	1997.0	2875737.6	
— September —	25"	4½	10415.5	14998406.4	
	26"	9	29468	42433920	
	27"	11	39834.8	57,362412	
	28"	8½"	27051.2	38954728	
	29"	1½"	1997	2875737.6	
	30th	36"	214544	308943360	
— October —	1st	18"	82892	119364480	
	2nd	12"	45,389.2	65,360448	
	3rd	6"	16048.4	23109696	
	4th	7½"	22429.6	32298624	
	5th	1"	1091.8	1572192	
	6th	1"	1091.8	1572192	
	7th	½"	386.5	556525.4	
			Grand total	935,489,374	cft

for year —

12,348,000 x 365 = 4,507,020,000 cft

4,507,020,000 x 7.48 = 33,712,709,600 gal

33,712,709,600 x 8.33 = 280,828,827,680 lbs

280,828,827,680 ÷ 2000 = 140,414,413.84 tons

140,414,413.84 ÷ 365 = 384,697.57 tons per day

July — 5" = 1½" = 1997.04 cft

" — 6" = 4" = 8734.4 " — 12,348,000

" — 7" = 6" = 16048 " — 24,652,800

" — 8" = 7" = 20,220.5 " — 29,117,666.4

" — 9" = 8" = 24698 " — 35,565,120

" — 10" = 6" = 16048 " — 23,109,696

" — 11" = 3" = 5677.3 " — 8,175,398.4

" — 12" = 2" = 3088.8 " — 4,447,929.6

" — 13" = 1" = 1091.8 " — 1,572,192

, and lost b

...225 ft		Hesserghatta tank weir 290 ft			Remarks
...cft ...ute	Total for 24 hours	depth of discharge	Quantity in cft per minute	Quantity in 24 hours	
		8 days 2 ft spillage on weir = 6969600 x 290 = 2,021,184,000 7 days 1 ft 2158128 x 290 = 625,577,400 1 day ½ ft 110,208 x 290 = 31,320,000	∴ Total 2,678,081,400		The whole of the sub series with the exception of the Byatha drain into Kakol tank - The combined catchment area is 89,305 acres and capacity of the tanks inclusive of capacity of Kakol tank 249 units = 650.913 mcft and adding this to the quantity 935.487 mcft discharged over weir of Kakol tank, the runoff from the whole catchment was 1586.402 mcft equivalent to 11.3 mcft per sq. mile during 1892 Details of Hesserghatta tank not kept - Talug Amildar states that there was a discharge of 2 ft over the weir for 8 ~~or 10~~ days - 1 ft for 7 ~~or 8~~ days, and lastly ½ ft ~~for what period not stated~~. ∴ Not reliable.
	238,986,800 cft			2,678,081,400 cft	

Note - Velocity of approach not known -

181

~~East of Arkavathy valley villages draining directly into the tank.~~

	houses	inhabitants
~~Harrohulli~~	~~41~~	~~150~~
~~Dasserhulli~~	~~"~~	~~"~~
~~Goondhulli~~	~~39~~	~~276~~
~~Total~~	~~157~~	~~576~~

Byatha and Hakol villages consist of 150 and 107 houses and contain 522 and 330 inhabitants, so that the total population located in the vicinity of the Hesse ghatta tank is only 2000, and I would submit, that being so small, the removal of the villages is unnecessary; but better sanitary arrangements are requisite, especially in the villages of Byatha - Hakol - Hodinaikenhulli and Goondahulli.

49 With regard to the necessity or otherwise of removal of villages I would mention that in Fanning's treatise on Water Supply it is stated as follows — "About one half the population of London, or one half million persons [illegible]

~~Contours at R.L. 65.00 once taken show that Ramsundra Pollia and Chick Devanpur on the West of the valley and Harrohulli & Goondhulli on the East will be on the margin of the tank, and these four villages must necessarily be removed.~~

received their domestic
supply from the Thames"
1875." "The drainage area
the pumping stations is
3675 Sq. miles, and minimum
summer flow is estimated to
350,000,000 imperial gallons
daily, and of this flow about
150,000,000 gallons is pumped
daily by water companies."
"Upon the Thames
above the pumping
there resides a population of
about 1,000,000 persons, includ-
-ing three cities of over 25,000
persons each, three cities of from
7000 to 10,000 each, and many
smaller towns and villages.
"The whole of the river and its
principal tributaries are under
the strictest sanitary regula-
-tions which the Government
is able to enforce, notwith-
-standing which a great
mass of sewage is poured
into the stream"

(Page 19)

Analysis of water

50 Specimens of water taken from the tank, and from the sluice of Hesserghatta - Byatha and Kak tanks have been forwarded to the Chemical Examiner of Mysore, but ×analysis of same has not yet been received - the water in the Hesserghatta and Kakol tanks appears to be good but that of Byatha is rather dis=coloured and probably contains vegetable impurities, which must be due to the wet cultivation below the Amane Maduray and Seere=sundra tanks having been ex=tended into the bed of the Byatha tank - this cultivation will I think cause much greater pol=lution of the water than any that can arise from the small villages, and wet cultivation should I think be certainly prohibited within 100 yards of the margins of the whole of the tanks comprised in the project

annexed

Brief description of project... 51 (a) It is proposed to impound 759·904 mcft of water in the eight tanks mentioned in para 28, and to deliver the same at the rate of 500,000 cft per day into filter and service reservoirs located on the man-tapam hill to the north of Bangalore (b) At Hesserghatta tank a water tower will be constructed with value at MS 2796·84, from which water will be led by means of covered masonry channel, 23,826 ft in length, with a fall of 1 in 5,000, to settling reservoir, located close to a pumping station situated a short distance from the Bangalore Tumkur branch of the S.M. railway, half a mile North West of the village of Banawar (c) From the pumping station the water will be raised to a stand post 42 ft in height, constructed on the top of the Banawar hill, the M.S.L. of which is 3097·64.

From

(Page 20)

(d) From the stand-post the water will be delivered in a cast iron main, 24" diameter, by gravitation, into filtering cisterns and service reservoirs, the combined capacity of which will be equal to five days supply (e) The floor of service reservoirs to be at R.L. 3750, which will give a sufficient head for an economical distribution to the Cantonment and city of Bangalore, the former of which being so ~~much~~ widely scattered, a maximum head is indispensable, unless the higher portions of Bangalore are provided with a seperate service, which it is quite possible might prove to be the most economical

(f) From the storage reservoirs service mains would be taken, one in a direct line to the Bangalore District office for the City, and the other to the Cantonment

Cantonment Railway
from which branches
be taken off for supply
Northern and Southern p.
of Civil and Military &c

52 Prior to entering into det.
of cost etc of the several item
of work, I would here ~~state~~ lena
that the project is analogo
to that ~~mentioned~~ referred to by Colo
H.M. Vibart, R E in para
2 & 3 of his letter etc. 29.
dated 20th October 1887, to the
Chief Engineer Madras Pr.
(vide page 247 of Memora
-dum of Bangalore wate
supply.) with reference to
which, I would ~~here mention~~ state
that I have recently investig
a project (details of which ar
given below) for the construct
of a dam across the Arkavati
river, at a site situated 2½
miles below the bridge on the
12th mile of Salem Bellary
road, for irrigation of 2or-

2000 acres of land on both banks of river; regarding which it is only necessary here to mention that construction of a dam impounding more than 154·310 mcft of water is impracticable without endangering the safety of the Southern Mahratta railway bridge across the Varne river.

Mean sea level of bed of river at
proposed site of dam ---- 2718·56
—Do— at crest of dam -- 2748·56
Quantity of water impounded — 154·310 mcft
Cost of dam ——— -- Rs 40,451
Cost of raising road bridge 15 ft — 16,566
Probable amount of compensation
for land submerged -- 8,940
Contingencies at 5 per cent - 3,297
Total Rs - 67,254

— Statement of probable cost of project —

Head Works 53. (~~1.1~~) Raising weir of Hessergpatter tank 15 ft in height.

Constructive details

Weir on left flank at R L 28[illegible] and 300 ft in length

Bund R L 2829·17 with to width of 15 ft

front slope $1\frac{1}{2}$ to 1 & rear slope 2 to

Revetment at R L 2825·17

Cill of sluice at R L 2796·84

Area (approximate) of water-spread at 2819·17 = 1044 acres

Capacity at R L 2819·17 = $2116\frac{1}{2}$ units = 552 611 m cft

a Bund - the right flank will be in continuation of the present cross bund, constructed during 1877 -

On the left flank a cross bund will be taken off at bend in bund, at a distance of 330 yards from the present weir (see C.S No. 5 - on plan) and from thence will be continued to the high ground

ground, where it tails off at
RL 2834·57

Earthwork 167,154 cyds
at 3 ans per cyd — Rs 31,341

— Do — 11,988 Do at 1/6 Rs 1,124

Old stone revetment 2190 cyds at 4/10 per cyd
= Rs 1,369

New stone revetment 16,356 cyds at 1/4 = Rs 20,445

Old stone revetment 1198 cyds at 4/12 per cyd
= Rs 899

(Stone to be taken from
the abandoned portion
of bund on right H. x.

Removal of Right Sluice } L.S. Rs 300
and refilling bund }

Ring Bunds at sluices } L.S. Rs 500
while undergoing removal }

Repair of left sluice to
allow of cultivation of
garden land from
water impounded bet=
ween new and old weirs L.S. Rs 500
10,916

Puddle trench and wall

Excavation 11,988 cyds at
1/6 = 3 }
Puddle wall 26,196 at 6/- } 10,916
= 9823 }

Total per bund 67,294

b Waste weir

[illegible]

and retain the present wei
to construct another weir
~~to construct another weir~~ ab
it, in the new bund on the ly
flank, as per plan — the ca
will be at R.L. 2819.17 and
at R.L. 2791.79 the weir wi
consist of a masonry body
with wings, masonry bind
walls, 39½ ft apart, in apro
and toe wall — the apron ben
soojient of the best ~~quantity~~ quality
1 yard in depth.

Brick in chunam 17,802 Cft
at 3/- per cft = —— 3,33
Plastering with mortar
31.05 Sqrs at Rs 3/- per Sqr —— 91
Soojient 6014 Cyds at 1/8
per cyd = —— 9,02
Earthwork, cutting
approach to weir * 6188 Cyds
at 1/- per Cyd = —— 386
Earthwork, cutting for
apron ~~etc~~ 64,253 Cyds at
2/ per cyd = —— 8,032
Earthwork, cutting
draught channel
from the weir * 146300 Cyds
at 1/ per Cyd = —— 9,144
c.o. 3001

[illegible] at
rate of 4 ans per Cyd which will
reduce rate of earth work for
weir to 1 anna per Cyd

Revetment to sides of apron and of draught channel above and below weir 1160 Cyds at 1/4 / . Cyd — — — — 1450

Stone slabs 8" at 8 ans per sqr ft 4159 — 2079

.x. .x. To be used for bund } for new weir

Total Rs 33,541

C. Repair of old weir

Brick in chunam 3444 cft at 3/- per cft — 646

Plastering with mortar 21.65 Sqrs at 3/- per Sqr — 65

Pointing with Portland cement 22.16 Sqrs at 5/- per Sqr — 111

Old stone Soojcent 46 Cyds at 11/10/- — — — — 29

Soojcent apron 3 50 Cyds at Rs 1/8 per Cyds — 5[illegible]

Stone slabs 8" 454 Sq ft at 8 ans per sqr ft — — — 227

Jelly packing to apron 1245 Sqr yds at 1/6 per [illegible] 1,712

Petty jobs L S Rs 100

~~Baling~~ Blasting L S Rs 150

Earthwork L S Rs [illegible]

Total for repairs of weir Rs 3615

ater Tower

(a) It was first proposed to take off the delivery channel through the left flank of the new cross bund at a short distance from the weir and to follow the left bank of the river, but longitudinal section taken along this line shows that it is impracticable, as the ground is cut up into numerous ravines, across which it would be impossible to construct a water-tight channel, except at a very heavy outlay; moreover for upwards of half a mile the channel would be below flood level of river. (See sheet No. 12) –

(b) In accordance with the Chief Engineer's instructions given on his inspection of the tank sections were taken along the right slope of the old abandoned [illegible] of tank. (See sheet No. 13) A delivery channel along this line is practicable, but would prove very costly as two breaches, one of which is very large one in the old [illegible] would have to be [illegible] an acqueduct 200 ft in [illegible]

would be required unless
Channel necessarily crosses
river. —

(c) The cost of filling in here
would amount to Rs 2680, a
that of aqueduct to Rs 3275,
addition to which a sum of
Rs 191 would have to be expende
on excavation — the total outla
would thus amount to Rs 6146,
although very heavy, would not
prohibetive, were it not that the
aqueduct would be insecure -
flooring of the delivery channel be
only 35 ft above flood level in Re
which would necessitate placing
the under surface of girders at le
77 ft below that level —

(d) The above mentioned line
being practically not possible,
another line was selected, whi
skirts the left end of proposed
cross bund, and then passes alo
the high ground, at a short dis
above the first line, quite clear
all ravines (See sheet No 14) —

(e) The excavation will be from
14 to 24 ft in depth, but cost,

Dam

same (Rs 2619) is much less than the cost of filling in the breaches and construction of aqueduct on line, and the alternative line, shown on sheet No. 14, is I think the only practicable safe one —

(f) The alignment of the delivery channel being necessarily a side of the weir, the water tower must of course be in a similar situation, and site selected is the margin of the present waterspread, at a distance of 600 ft above the new weir, and well out of line of draught to it

(g) The water tower will be similar to that constructed at the Bangalore waters supply reservoir (vide sheet No. 17) the only exception being that valves will be placed at sluice openings instead of wooden shutters —

(h) The tower will be [illegible], 6 ft internal, and 15 ft external diameter, with [illegible] at R. L. 2804.28 and 2811.72 and top at R. L. 2823.17, [illegible] ft above crest of weir —

(i) A [illegible] 676 ft in [illegible] be constructed from the water tower in which a [illegible]

fixed and filled with
water tower and at each.—

55. — The approximate cost of
work is as follows.—

a. Earth work

Excavation for open channel
water tower Cyds.

Excavation for tower Cyds — 167.

For tunnel from tower Cyds — 1605.

Total Cyds 1770 3 at 2/6 = Rs 270

b. Concrete in Soorkhi.

For foundation of tower 18½ × 18½ × 2' = 684

For foundation of tunnel 750 × 13 × 2' = 1950

Superstructure of tower ——— 5660

Total Cft 25 844 at
3/3 = Rs 523

c. Stone in Surkhi mortar

For foundation of tower Cft 919

For foundation of tunnel Cft 19500

Superstructure of tower ——— 1300

Total Cft 21719 at
= Rs 4412

d. Cut stone work

For tower Cft 788

Total Cft 788 at 1/0 = Rs 781

Dressed Quoins — 1278 sq ft at 4/- = 3

Brick in Surkhi mortar.

Ventilating shaft Cft 1128

Side walls of tunnel Cft 11,250

Total Cft 12378 at 3/3 = Rs 25

f. Arch work in Soorkhi Mortar

For tunnel 25,000 Cft at 6/- Rs 9375

g. Stone slabs 8" dressed

For floor of tower sq ft 137

For floor of tunnel sq ft 6375

Total sq ft 6532 at 12/- Rs 4897

h. Cast iron flanged piping 30" diameter

and 1" thickness of metal

50 rug ft weighing 2.98 cwt per ft run - 149 cwts

at Rs 9/8 per cwt - Rs 1415

i. Carriage to site and fixing

750 ru ft at 1/8 per ru ft - Rs 75

k. Open channel as per sections in margin

700 ru ft at Rs 3/- per ru ft Rs 2,100

j. Valves 30" double faced with gun metal

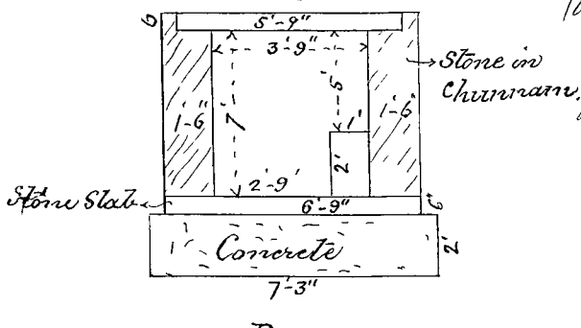
(inclusive of carriage etc)

No. 5 at Rs 750 each - Rs 3750

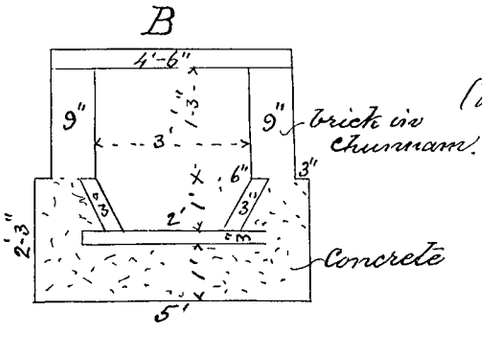
Total cost of water tower Rs 37,663

56. Delivery channel

A



B



(a) To be of section A (given in margin) from end of tunnel of water tower up to the 34th chain [illegible] where it [illegible] with ventilating [illegible] every 10 chains.

(b) From the 34th chain [illegible] will be of section [illegible] aqueduct at [illegible]

-port, and silt-traps at chains — the fall throughout be $\frac{1}{5000}$, and both sections of ch will discharge more than the re quantity (5·787 cft per second) w flowing 2 ft in depth. — —

(c) The channel as now aligned very crooked, and, in addition the alterations in the first 54 ch several other deviations will necessary, the principal being o chains 72 to 120 — from chains 162 to 178 and from 270th to 305th. — —

(d) From 54th chain to 83d chai the channel passes through dry cultivation — at 83d chain it ente gardens and continues in these up to 108th chain — the crossing of the cody nullah of Aivardanapure tank is at the 99th chain, where flo of channel is at R. L. 2792·34 an bank of nullah (which is frequen topped) at R. L. 2796·89.

(e) This portion of channel (from 72d to 120 chain) must be altere and longitudinal section of de -ation is given in Sheet No. 15, fo which it will be seen that the length of the channel can be dec

by 2446 ft — the channel will be raised above the level of the ground for a distance of 688 run ft, and some arrangement will have to be made for irrigation of land lower down the valley, as the present earthen dam across cody channel, by means of which irrigation is now carried on, must be removed — the cost of such work will however be more than counterbalanced by savings in length of channel.

(f) From the 120th chain the channel runs close to the Hirardanapura irrigation channel up to the 126th chain, from where it turns to the left and runs through dry cultivation up to the 162nd chain, where it enters the wet cultivation below the Harthichikenhully tank — from 162d to 178th chain the channel crosses this wet cultivation, and alteration of alignment will here be necessary, which will decrease the length of channel by 528 ft — the whole of the channel (5. ft in length) of this realignment must be carried above ground lev

(g) From 175th chain to 241st chai the channel runs through dry cultivation — from 241st to 250th [illegible]

black cotton soils, where
of alignment is necessary—
to 289 the channel passes
cultivation, and from this
it follows the railway up to
Cham—from 270th to 305th chain
alignment should be altered.
a further saving ~~survey~~ in length of over
chains can be made.—

(h) At 305th chain the channel
leaves the railway and runs to
left, passing over very broken grou
between 330 and 352 chains, an
crossing the cody nullah of Kumba
hully tank at chain No. 335.—the
channel between 330 and 362 chain
should be carried higher up, and
cody channel should be crossed
200 ft above present crossing.—

(An aqueduct 20 ft in length
will be wanted across the Kumba
hully drainage.)

(i) From 352 to 376 chains the li
of channel runs through the we
cultivation below the Kumba
hully tank, and at 380 it cross
the combined cody, nullah of the
Banavar and Gangaothully tan
—(an aqueduct 50 ft in length
on the left bank. is here necessary

(j) At 383 a rather deep nullah is crossed, but a little
higher up it tails off, and lower down forms
an irrigation channel, consequently all that is
is to throw up a chain across it, and construct a sluice
for irrigation on left bank.—

(k) From 386th chain the ground rises rapidly on all sides, and the channel cannot be continued beyond the 390th chain without necessitating deep cutting, which would add greatly to the cost of the settling reservoirs, which are proposed to be placed at end of delivery channel.

57. Approximate cost of delivery channel.

a. Earthwork excavation and refilling for first 660 ft from end of tunnel up to line with weir -- ---- = 17934 cyds.

beyond line of weir up to commencement of chain No 1 -- 1056 ft - 24567 cyds

From 1st to 50th chain = 3300 ft —— 20955 cyds

Tot cyds 63472 at 3/6 = Rs 13,884

b Delivery channels as per section A

From end of tunnel to 50th chain 5016 rng

at Rs 10/6 ——

Rs 52041

c. Ventilating shafts and silt traps

From end of tunnel to 50th chain

No 8 at Rs 1751

Rs 1400

d. Delivery channel as per section F

18,810 ft at Rs 4/- - Rs 75,242

Fencing line and drainage

4.51 miles at Rs 300 per mile - Rs 1353

Compensation for land

12 acres at Rs 35/ [illegible]

[illegible]

Acqueducts

No. 4 aggregating 1278 rung ft

at Rs 4/- per rung ft = Rs 5

Silt traps

One at every 10 chains

No. 34 at Rs 10 = Rs 340

Total cost of delivery

Channel ___ 149,790

58 A: Settling tanks.

(a) At the end of the delivery channel it is proposed to have two settling tanks, each to hold a day supply — the tanks will be 214 ft sq at bottom, and 10 ft in depth, with slopes of 1 to 1, and will be floored and lined with 1½ ft of brick in Surkhi, plastered throughout with Soorkhi Mortar.

(b) The site selected for the construction of the tanks is a favorable one, there being four feet of "red soil" with clay underlying it.

The cost of the work will be as follows.

a. Earthwork excavation

27,876 Cyds at 2/- = Rs 3,48

b. Brick in Surki - 88,854 cft 3/- = Rs 16,60

c. Plastering with Soorkhi Mortar

592·36 sqrs at 3/- = 1,77

Cum

d. Pumping well (constructed with Portl cement) L. S. Rs 150

e. Land

2 acres at Rs 36/- = 72

Total Rs 22,143

For two tanks Rs 44,286

59. Pumps and engines.

(a) Well be fitted up immediately above the settling ponds, at a distance of 150 yds from the S. M. railway l. -

(b) Allowing 24" as maximum diameter of pipe main, and that it is necessary, with reference to economy in cost of distribution, to have the floor of service reservoir at R.L. 3055 - the lift will be 354 ft as per details below.

(c) Level of floor of service reservoir 3055.00

Head necessary to discharge 500 000 cft in day of 13½ hours in 24" piping, the length of main being 36960 ft = 74 00

Loss in filtering and service reservoir ——— 10 ft

R.L. 3134 ft

Floor of settling tanks R.L. 2782

Difference — 357 ft

Pumping main 8,580 ft in length, 24" diameter, to discharge 6173 cft per minute, head required 1[illegible] ft

× Deduct 20 ft for suction — Total lift × 7[illegible]

(d) The agent
Pumping Company
been addressed
inclusive of delivery and
two triple expansion engines
Babcock boilers, each
to lift 3,858 gallons per minute
to a height of 354 ft, through
$1\frac{3}{4}$ miles of 24" rising main, and
on receipt of × reply the actual cost
of this Sub head of work will be
given, but in mean time, to
of completion of approximate esti-
mate, a sum of Rs 2,000,000 has
been allowed.—

× Telegram dispatched and reply to the following effect received—
"We can only quote for high pressure and compound, all triple expansion made under royalty by S. Simpson & Co— Pimlico London"
In reply to a subsequent telegram, asking for quotation for compound engines, the Agent telegraphed—
"We have cabled for special quotation and will wire you on reply."—

(e) In order to reduce the lift as
much as possible pumping for
$13\frac{1}{2}$ hours per day has been allowed
but, as in any case relays of men
would be necessary, this as well
as the additional pumping of
7 hours twice per week, necessary
to keep up the supply, and allow
of a day's rest on Sundays, can
be done without difficulty.—

60. Rising Main.

(a) Will start from the 398" chain
and be laid in a straight, the

30)

to the top of the Banawar hill (517" chains) where it will be joined on to the stand post — at the 416" chain the line of piping crosses a nullah 50 ft in width and [illegible] ft in depth, from whence up to the railway (421st chain) it runs [illegible] broken ground — the line crosses the railway diagonally, at the [illegible] post 200/19, [illegible] in depth, and a tunnel will be necessary — at the 442nd chain the line of piping crosses two [illegible] and will have to be [illegible] on masonry pillars for a distance of two chains — from this to top of hill there is [illegible] of much consequence. (b) The main will be of 24" socket [illegible] piping and 8,580 ft in length, the thickness of the piping being [illegible] the [illegible] inclusive of socket will be 2·37 cwts per ft run 8580 × 2·37 = 20234 cwts

at 7/12 per cwt = Rs 1,57,588

(c) Laying pipes 8580 running ft of 24" piping

at Rs 1 per running Rs 8,580

Grand Total for R's [illegible] 1,66,[illegible]

61. Engine and boiler [illegible]

with chimney [illegible] Rs 2,[illegible]

62. Quarters for establishment

[illegible] Rs 16,00

63. Stand post —

(a) To be 42 ft in height [illegible] of Banawar hill the R. L. of [illegible] is 3097.64

1⅛" thickness of metal to be a special castings throughout be necessary, as bends at must have proper seating flanges of piping must have t

(c) For 30 ft in height the post will be carried up in masonry tower, which will as a watchman's post and Signalling station, Consequ struts and braces will be requisite for the upper 12 ft only

64. Details of cost

Tower (8 ft octagonal)

a) Stone in chunam - foundations 266

Basement ——— 57

Superstructure ——— 1282

1,595

at 3/6 = Rs 349

(b) Doors and windows ——— 50

(c) Roofing slabs and terrace — 30

(d) ladder with trap door ~~cast stones~~ — 50

Total Rs:- 479

(e) 24" flanged tubing

68 ft straight tubes with special flanges

30 ft of bends &c

Total 98 ft 2·75 cwt per ft

= 269½ cwt at 10/8

= Rs 2830

Turning

F. Fixing piping

98 ft at Rs 2 = 196

Grand Total Rs 3,

165. Delivery main.

(a) There is a nasty dip just beyond the brow of the hill, but this can to some extent be avoided by a slight detour to the West.

(b) At 783d chain the line crosses the S. M. railway, and at 893d chain the B. H. railway flows 864th to 881st chain the line passes through the bed of the Yessenthpur tank, but no deviation will I think be necessary on this account, as the soil in bed of tank is hard and clayey.

(c) The total length of the main is 36,960 ft, in which for 18,678 ft, or more than half the length, the head is less than 140 ft, but no alteration in thickness of metal in pipes has been made on this account, as 1" is the less thickness that can be allowed for 24" piping with [illegible] to [illegible]

66. Cost of Main.

a. 36960 run ft of 24 piping with 1" thickness of metal - weight 2·37 cwt per ft re = 87595 cwt at Rs 7/12 per = Rs 6,73,861

b. Laying pipes 36960 run ft at R 1 pe = Rs 36,960

c. Air valves 5 at Rs - 200 = Rs 1000

d. Scour valves 6 at Rs 150 = Rs 900

e. Sluice valves 4 at Rs 520 = Rs 2080 with spigot & socket faced tail pipes

f. Reflux valves 6 at Rs 500 = Rs 300

Grand Total for delivery main Rs 7,17,

67. Filtering reservoirs.

(a) Will be similar in construc to the settling tanks, ie, reservo sunk below ground level, floore and lined with 1½ ft of brick Chunam

(b) Three each 144 ft square, two of which will filter a day's supply at the rate of 70 gallons per sq ft in 24 hours - the filtering strata ~~should~~ to consist of sand, charcoal and stone jelly 2'-6" - 4" & 1 ft in depth respectively.

68. Cost of Reservoirs

a. Earth work excavation.

11271 cyds at 2/4 = Rs 1409

Brick

b. Brick in Soorkhi Mortar

47,109 Cft 3/- - - Rs 8,333

c. Plastering with Soorkhi Mortar

399.7 sqrs at 3/- - Rs 1197

Total - 10939

for 3 reservoirs - 32817

69. Service reservoirs

(a) Construction to be similar to that proposed for filtering reservoirs with the exception that it will be covered with stone slabs carried on stone pillars 1 ft sqr, fixed 9 ft apart from centre to centre, which will be founded on stone slabs laid 1½ ft below foundation of floor of reservoir

(b) Reservoir to be 10 ft in depth and to store 5 days supply or 1,500,000 cft

70. Cost of Service Reservoirs

a. Earth work excavation

72,150 cyds at 3/- - Rs 9019

b. Brick in Soorkhi

277,200 Cft at 3/- Rs 1178

c. Plastering with Soorkhi Mortar

1882.80 sqr at Rs [illegible] sq Rs 6[illegible]

d. Stone slabs for foundation of pillars

12420 sqft at 3/- - Rs [illegible]

e. Stone pillars 14'x1'x7" (dressed)

No. 2070 at Rs [illegible] - Rs [illegible]

f. Stone girders 9'x1'x8'

No. 2100 at Rs [illegible] [illegible]

g. Stone slabs 9"x12"x3" wide

186,979 sq ft at 3/4 = Rs 3,5

Grand Total Rs 1,21,7

11. Distribution

Rs 3½ per head for population

of 250000 = Rs 8,75,00

12. — Compensation

a. Land thrown out of cultivation below Neeserghatta tank.

Wet land - 202½ acres at 75

= Rs 15187

Garden land 110½ acres at Rs 100

= Rs 11050

Total 26137

Deduct probable receipts

by sale of land formerly

cultivation 313 acres

at Rs 36/4 ——— 11268

Net compensation to be paid 14,869

b. Land thrown out of cultivation belo

Byatten tank.

Wet land 75½ acres at Rs 75 = Rs 56

Garden land 10½ —— Rs 100 = 10

Total Rs 6,812

Land thrown out of cultivation

below Kahal tank.

Wet land 123¾ acres at Rs 75 = 9,28

Garden land 11¼ at Rs 100 = 1,125

Total Rs 10,70

ge 33)

C. Land submerged by raising weir of Hesserghatta tank.

Wet land — See statement of wet land below Byatha and Kakol tanks

Dry land — ~~513~~ ×643 acres at Rs 36 per acre — Rs ~~18,468~~ 23,148

× In addition to this 158 acres of wet land now lying fallow below Byatha and Kakol tanks will be submerged

* Grand Total Rs ~~[illegible]~~ 65,472

× Details for the five minor tanks cannot be given as revenue sl for same have not yet been received from the Revenue Authorities.

* Revenue statements for four tanks since received —

A. Sonnenhully — Land thrown out of cultivation —

wet land 44 acres at Rs 75 = 3,300
garden land 2 " at Rs 100 = 200
Total Rs — 3,500

Chick Devanpur

wet land 28 acres at Rs 75 = 2,100
garden — 2 " at Rs 100 = 200
Total Rs 2,300

Dyvara Kunte

wet land 25 acres at Rs 75 = 1875
garden 6½ " Rs 100 = 650
Total Rs 2,525

Arasin Kunte

wet land 19½ acres at Rs 75 = 1462
garden 1½ acres at Rs 100 = 150
Total Rs — 1612

Jambunkere

wet land acres at Rs 75 = —
garden — " at Rs 100
Total Rs —

73. Abstract of cost of Project —

Present value of 8 tanks comprising project (see statement page 6) — Rs 1,04,795

Head works — Bund — 67,394
Waste weir — 33,541
— Do — 3615
Water lower — 37 6[illegible]
2,47,008

Delivery works

Masonry channel — 149,190
Settling tanks — 4[illegible]
Pumps [illegible] — 2 00 000
Rising [illegible] — 1,66,168 ~~[illegible]~~
Engineered [illegible]
[illegible] — 20 000
[illegible] — ~~[illegible]~~
5,80,244

Brought forward —

Quarters for establishment	16.000
Stand post	3,50[illegible]
Delivery main	7,17,8[illegible]
Filtering reservoirs	32,817
Service reservoirs	1,21,733
Town distribution	8,75,000
	~~23,47,150~~
	~~23,38,520~~
Incidental charges	65,47[illegible]
Compensation for land	~~50,850~~
~~Totals Rs.~~	1,29,70[illegible]
Contingencies at 5%	~~1,29,276~~
Establishment 15% on Head works, Masonry channel, Settling tanks, engine and boiler house, quarters for establishment, Stand post, Filtering and service reservoirs	95,27[illegible]
Establishment 5% on other items	97,94[illegible]
	~~97,490~~
	29,82,5[illegible]
Grand Total Rupees	~~29,58,41[illegible]~~

R. Cardwell

10th January 1923

Executive Engineer,
Bangalore Division.

74 — Loss of Revenue.

34)

※ Particulars with regard to this item can only be given for the Hesserghatta, Byatha and Kakol tanks, as revenue statements for the five minor tanks have not yet been received, notwithstanding several reminders have been sent to the Revenue authorities on this subject.

※ Information since received with regard to other tanks —

	Wet land	Garden	Total
Sonnenbully	Rs 220	15	235
Chick Dwarapum	142	19	161
Dywara Kunte	112	12	124
Arasinkunte	82	3	85
Kumbunkere	—	—	—
Total Rs			605

Hesserghatta tank.

Wet land — Rs 1216
Garden land — 628
Total Rs 1844

Byatha tank.

Wet land — Rs 493
Garden land — 78
Total Rs 501

Kakol tank

Wet land — Rs 792
Garden land — 51
Total Rs 743

Grand Total Rs 3,148

Deduct probable revenue from land below Hesserghatta tank if leased as dry land 313 acres at Rs 2 — 626

Net loss Rs 2522

Add loss of revenue on four tanks noted in margin — Rs 605
Do on 643 acres of dry land submerged — Rs 965
Grand Total — 4,092

R. Caldwell

Dr. 10th June

Newyhatta - Tanks

Physical Examination	a true from the Tanks
Color	Slightly cloudy
Smell	none
Taste	none
Reaction	Neutral
Lime	present
Chlorine	a trace
Sulfuric acid	none
Nitric	none
Amonia	trace
Sulphuretted Hydrogen	none
Hardness Total	19 grs of carbonate of lime per gal
Permanent	13 6 - Chloride of calca (mainly)
Removable	5 4
Organic matter	—

Water taken from Sluice cistern

Almost precisely the same, only the amount of hardness both total Permanent is a triple, less int.

Letter speaks of

Opinion — From the analyses I consider the water a good potable one, it might be a trifle less hardy, the total hardness is nothing like sufficient to render unfit in any way for drinking purposes, it being just a trifle harder than the water in the Kirkcaldie Reservoir at Mysore. —

Regatta

Two specimens sent

A Tanks water

Color	faint and cloud
Smell	none
Taste	none
Reaction	Neutral
Lime	present
Chlorine	a trace
Sulphuric acid	nil
Nitrous	nil
Ammonia	nil
Sulphuretted Hydr:	nil
Magnesia	a trace
Total Hardness	Hardness 25 5 grs of ca carb per gall
Permanent	18 5 ca c Magnesia salts
	Removable

7.0

matter represented ~~xxx~~

Water taken from the Sluice

Almost identical with the above only it is a trifle less hard
The water from the tank may be said to be a fair potable
one and quite fit for use

(Initialled) P H B

Lakole Tank Two specimens.

Water from the tank

Color	white
Smell	Slightly Earthy
Taste	none
Reaction	Neutral
Lime	present
Chlorine	a trace
Sulphuric acid	nil
Nitric	nil
Amonia	nil
Sulphuretted Hyd:	nil

[illegible] ardness 15.40 grs of Ca CO_3

Permanent 12.30 Ca Cl magnesia

Removable 2.10 – Ca CO_3

Organic matter

The other sample is precisely the same

[illegible] water [illegible] for [illegible] best of the samples [illegible]

[illegible] the [illegible] of these tanks being used as water [illegible] for [illegible] it is [illegible] that they would all be conserved in which case the water would [illegible] better than it is at present.

[illegible]

19th January 1893

78

Present value of eight tanks	1,04,795
— — Four other tanks proposed to be included in project	12,000
	1,16,795
Compensation for land thrown out of cultivation and submerged for twelve tanks (approximate	74,000
Head works	1,90,795
Bund	67,394
Waste weir	33,541
Repair of old weir	3,615
Water towers	37,663
Grand Total	1,42,213
	3,33,008
4 % per annum on above	Rs 13,320

Loss of Revenue — Rs 3700

Value per annum of 500,000 cft of water per day at 8 ans per 10,000 gallons = Rs 10,585

Value of water delivered in Cantonment at 4 ans per 1000 gallons Rs 2,84,700

Preliminary report on the Project for supplying the Civil and Military Station and City of Bangalore from the Hassarghatta Reservoir.

Introductory Remarks -

The Arkavathi river. - 1. Amongst the voluminous papers connected with the Bangalore Water Supply the proposal to utilise the waters of the Arkavathi river is several times mentioned the idea being apparently to dam up the river and pump up the water through pipes, but no details were worked out: the proposal to take water from the Hassarghatta Tank — /Latitude 13°-9' Longitude 77°-31¾ See map attached to report./ situated on that river is also referred to, but seems to have been abandoned on the

Reduc

Scope of and lift.—

2.— The subject of the Water Supply has been in= =vestigated by several Officers and their investigations show clearly that it is absolutely impossible to get a suffe cient supply for even the Civil and Military Station alone by gravitation, and that pumping must be resorted to.— Previous

3.— It is also shown clearly that to get an unfailing supply in a year of deficient rainfall, the Catchment area must be of considerable extent and the only such Catchments are that of the Panakini river to the East, and that of the Arkavatti river to the West of Bangalore. Existing large Catchments

.— Projects have been prepared or proposed for getting large Catchment areas nearer Bangalore by Increasing existing Catchments.

by means of long Contour Channels extending to several different water sheds and by buying up Series of tanks but none of them are by any means satis= =factory and the two Catch= =ments mentioned above are the only ones from which an almost unfailing supply can be obtained, an absolutely unfailing supply is of course an impossibility as with no rain or nearly none, there would be no water, whatever Scheme were adopted

Arkavatti and Panakini Catchments-

5.— As regards the two sources of supply the Arka= =vatti is by far the most satisfactory as it is nearer, higher and contains better water, and therefore the Panakini need not be considered —

Dam across Arkavati river.—

6.— To build a dam across the Arkavatti river

below

the Hassarghatta Tank as was proposed by Colonel Vibart, R.E. would be waste of money as the bund of that Tank already forms a dam across the river at a higher level and only wants raising slightly to answer all requirements and it has consequently been settled to use the Hassarghatta Tank as the reservoir of supply. —

7. — The idea of investigating the Hassarghatta Scheme originated with the present Dewan Sir Shashadri Iyer and he wrote a Memo: of instructions dated 31st October 1892, giving data on which the investigations were to be made, these were

1st The Scheme to allow for a population of 250,000 people. —

2nd The supply to be 2 cft. or 12½ gallons per head per day. —

3rd

Instructions given by the Dewan. —

3rd The reservoir to contain a supply of 3 years. —

Remarks on the Dewan's instructions, population

8. — As regards No. 1, the population in 1881 was 1,55,857 and in 1891 - 1,80,366 showing an increase of 24,509 or 157·2 per 1,000, so that in 1901 the population will be 2,08,740 and in 1911 it will be 2,41,437, therefore in 20 years the figures laid down by the Dewan will not be reached, and though it is advisable to allow for 10 years increase as it is believed is done in all water supply Projects it does not seem right to tax one generation for the water supplied to a future one. It is therefore considered that the supply should be limited to that required for a population of 2,00,000.

Q.— regards No. 2. data,
the supply to be given per head
per diem depends on whether
the Scheme is to be complete
in itself or whether it is
to supplement the supply
received from wells and
other sources, in the former
case 12½ Gallons is none too
great but in the latter 10
Galls per head ought to
suffice, and as there is no
doubt that a good part of
the population will still
resort to wells, it is thought
that only 10 Gallons per head
should be allowed, and it
must be remembered that
in most of the water supply
Schemes hitherto, referred
for Bangalore the supply
for the native population
of the town has been taken
at only 6⅔ Gallons and this
should be considered in
comparing the cost of this
with other projects.—

It

"It will be well here to quote from the Memo: of Colonel Hasted Chief Engineer Madras, on the Bangalore Water supply, in para 6 of which he writes "It will be well here to consider the quantity per head per diem that should be provided. In the Schemes that have been proposed, this quantity varies very considerably the highest being 20 gallons and the lowest for drinking purposes alone about 2 gallons. The ordinary allowance in England in non-manufacturing towns is 16 to 20 gallons, but in this Country when water is not required for Closets or for washing clothes it may be very much less. Major Kennington says in Mysore according to very carefully prepared statistics, the consumption was found

10 in 1874 1¼
a head per diem at the highest estimate. Surgeon E. Nicholson who was for a long time employed as Analyst of waters in Mysore in his report dated 18th December 1871 on the water supply of Bangalore puts down 3 gallons a head per diem for every man, woman, and child as very liberal. The supply provided for the troops in Captain Romilly's estimates, the latest approved by Government was about 12 gallons per head per diem, and it is considered that a very ample supply will be provided if 2 cubic feet or 12½ gallons are allowed for the troop and 1 cft. or 6¼ gallons for the native population".—

[illegible]

10.— As regards the 3rd data it is not very clear if the Dewan meant that the

Storage.

the Reservoir was to contain a three years supply independant of rain falling during that time and including evaporation and absorbtion; if so, the capacity of the Reservoir will have to be enormous (about 1,100 millions cft.) and it is considered if it be large enough to contain a 2 years supply of 10 gallons per head for a population of 2,00,000 people, including evaporation and absorbtion and assuming that all of these years will be years of the lowest known rainfall, it will be all that is required. —

Mr Caldwell's report. — 11. — In accordance with the Dewan's Memo: Mr. Caldwell, Executive Engineer Bangalore Division was ordered on the 2nd November 1892, to prepare a preliminary report on the Hassarghatta

Water

Water Supply Scheme and this report which he has prepared with great care was submitted on the 10th of January.—

12.— The supply allowed by Mr. Caldwell is as laid down by the Dewan that is 12½ gallons per head for 25,0000 persons or 5,00,000 cft. per day equal to 182.500 Millions of cft. per Annum, but he only allows a storage capacity in the Hassarghatta and other Tanks above (to be described hereafter) of 870.22. Millions cft which would be about ⅓ that required by the Dewan vide para 10.—

Storage allowed by Mr. Caldwell

13.— Supposing 2,00,000 people were to be supplied at the rate of 10 gallons 1.6 cft. per head per day, this will require 3,20000 cft. a day or 116.8 Millions cft. per year and the capacity allowed

Storage required for 2,00,000 persons at 10 gallons per head.—

allowed by Mr Caldwell would be more than 2 years supply without any rainfall being added. —

Mr Caldwell's figures adopted in this report.

N.B. — In this report Mr Caldwell's figures will be adopted, but it will be shewn what the results would be if the smaller ones were taken.

Brief description of Project. —

Tanks included in Project.

15 It is proposed to bring up the 8 lowest tanks of the Hassarghatta Series; these are (vide Sepo: Map herewith)

Hassarghatta.
Byatha.
Kakol.
Samambally.
Chick Devenpur.
Tumbinakere.
Arsinakunta.
Dyavara Kunte.

All these will be left as at present with the exception

of

of the first named (the terminal Bank) which will have its weir raised by 15'.

16.— In these Banks 870·22 Millions of Cft. of water will be impounded and from the Hassarghatta Bank the supply required for the town will be drawn off and carried 23826 Ft. in a masonry Channel to a Settling reservoir near Banawar hill from whence it will be pumped to a Stand pipe 42' high on the top of that Hill (level 3087.64) and from this standpipe the water will be delivered by Gravitation through a 24" Cast Iron Main to a Service Reservoir and filter on Hauntapam Hill from whence the distribution to the Civil and Military Station and the City will be taken off.

(Delivery

17. — The Project is a simple one on an Engineering point of view the chief points to be considered and discussed before the details are worked out being: —

1. Quantity and storage of water available.
2. Quality of water.
3. Cost of Project. —

It has been proposed to build the service reservoir at a lower level, the water required for the higher parts of the station being pumped up separately. the average level of the Pettah may be taken at under 2,970' and therefore a reservoir with floor at 2,980 would suffice, but there are many parts of Bangalore above this level such as the railway station and the houses in the vicinity the Residency, the Palace, the Jail, the Government buildings, houses in the neighbourhood

neighbourhood of St. Marks and Saint Andrews Churches and the High ground and a large volume of water would have to be separately pumped and this is not thought advisable owing to the cost. To command the high parts of Bangalore mentioned omitting only the High ground and railway station, a service reservoir floor about 3,025 would be required and it is thought better to pump the ~~30'~~ extra. 30' once for all than to have separate arrangements.—

Quantity of water available —

Present and proposed Capacity of tanks.

18. In para 6 to para 28 of his report Mr. Scaldwell has described in detail the present condition of the 8 Tanks to be taken up, so it is sufficient here to state that the total capacity

of

of all these Tanks is at present 206.736 Millions of Cft. and with the weir of Hassarghatta raised 15' the capacity will be 384.577 Millions of Cft., but the 5 Tanks named last in para 15 may be omitted as they are very small and shallow, the total capacity will therefore be 870.22 - or say 870 Millions of Cft., which excluding evaporation and absorbtion is more than the 3 years supply of 547.5 Millions of Cft. laid down by the Dewan and would be more than 3 years of the reduced supply recommended in para 30 evaporation and percolation being included. —

Catchment area.

19. The total catchment area of the Hassarghatta Tank and the 183 Tanks above it is 211.78 Square miles

and

and the free catchment of the 8 Tanks to be taken up is 22·78 square miles.

20. — In addition to this there is a catchment of 8·85 Sqre. miles, vide Statement C. attached to Mr. Caldwell's report that is free to the extent of $\frac{2}{3}$rds of the run off during ordinary years and ½ during years of minimum rain fall, the capacity of the Tanks in that area being so small that even in the worst years not more than ½ the run off can be impounded, therefore 4·42 square miles may be added to the 22·78 giving a total of 27·20.—

Extra. Catchment.

21. — An additional area of 3·21 square miles may be obtained by throwing out of cultivation the four very unimportant Tanks mentioned in Mr. Caldwell's Statement

Additional Catchment proposed.

Statement D, this would bring the total free catch=ment to 30·41. As these tanks can be bought for very little it is advisable that this be done. —

Rain-fall.

22. — No reliable rain=fall registers have been kept at any stations in the Hasserghatta catchment. Mr. Sealdwell submits state=ments of the rainfall for the last 3 years at Nela=mangala, Dodballapur and Yellalanka; but these cannot be depended upon; therefore the figures for Bangalore must be accepted though judging from the geographical position it is probable that the rainfall is greater in the Arkavathi valley and this opinion is borne out by those who have had many years acquaint=ance with this valley. The average yearly rainfall at Bangalore may be taken at

at 35," the minimum at 17" and the Maximum at 56."—

23.— What amount of run off can be counted on is always a doubtful point as it depends on the nature of the rain-fall; with a yearly total of 40" if the rain fell in small showers at considerable intervals the run off might be less than with a yearly total of 20" in which there were two or three heavy down pours.

The percentage of run off also diminishes with the ~~main~~ increase of catchment area

Run off from Ca

24.— From the records of Sankey's Tank the average run off is about 14 per cent of the rain fall while the least is apparently 9 per cent, but there appears to be some error about this last figure or else it is due to the catchment channels being

Run off from catchment of Sankey's tank

being out of order for this small percentage was received in 1888-1890, when the rainfall was 31.12" and 34.37" respectively while in 1884 when the rain-fall was only 21.67" the amount received into the Tank was 17 per cent.—

Assumed run off from the Catchment of Sankey's tank probably incorrect.—

25.— It has generally been assumed that in the case of Sankey's Tank the amount of run off from 1 Sqre Mile of Catchment is 7 Millions cft. in a bad year 11 millions cft. in an average year and 17 Mns. cft. in a good year (vide para 4 of Chief Engineer Colonel ~~Maclean's~~ note on Bangalore Water Supply dated 14th July 88 and Colonel Bowen's note on Lieut. Fischer's Nebbal Scheme) and these figures have been adopted by Mr. Realdwell in calculating the run off at Hasaraghatta. But they

are

apparently
are ~~evidently~~ incorrect
as they mean that in a
year of 17" of rain the run
off would be about 18
per cent, in a year of 35"
~~fall~~ about 14 per cent,
and in a year of 56"
about 12 per cent and this
is quite contrary to what
is known to be a fact
viz: that as a rule the
percentage of run off is
less ~~than~~ proportionately less than the rainfall.

26.— In many of the
~~Water Supply~~ Schemes that
have been prepared the run
off has been taken at 13
per cent of the rainfall in a
bad year and this amount
is calculated on both by
Mr Standish Lee and
Major Grant, R.E. in the
Madigal project and
taking the nature of the
Madigal Catchment
into account this figure
is probably not too high,
but

Run off assumed in other projects and amount allowed in this one.

but in the case of the Hassar=ghatta Catchment which is partly cultivated and not steep 8 per cent is perhaps as much as should safely be allowed in a year of a minimum rainfall of 17 this will give a run off of 3·15 Millions cft. per sqre. Mile.

Run off laid down by Major Kensington from tank catchments generally and amount calculated on in this project.—

27.— The late Major Kensington, R.E., who was intimately acquainted with the Tanks in the Province has laid down that the run off in ordinary years from a catchment similar to that of the Hassarghatta and which he describes as follows: "Red or black soil, porous, cultivated or scrub jungle or grass, catchment flat, is 20 per cent, so it will be safe to take 15 per cent or 12¼ Millions - say 12 Millions as the run off from

1 sqr.

1 square mile. Therefore during an average year of 35" rainfall the total run off from the 30.41 sqre. miles will be 371.72 Millions cft. and only 95.79 Millions in a year of 17" fall. The run off from Sankey's catchment in 1892 was 11 M. cft. per sqre. mile rainfall being 27".

Run off from Kakol tank catchment (see ~~with~~ Mr. Scaldwell's table F) was also 11 M. cft. a sqre. mile with rainfall below the average and these are both far in excess of the run off allowed in the calculations in this report. —

Supply from upper t in an average year

28. — As the capacity of the 8 Tanks included in the Project is 884 Millions of cft. vide para 18 it follows that in an average year the supply will not fill them but it will be seen from Mr. Scaldwell's table B the capacity of the

the other upper tanks in the Hassarghatta Series is 5,075 units or 1,319 Millions cft. and the catchment area being 189 sqre. Miles the run off would be 2,315 Millions of cft. which would fill all the Tanks and leave a surplus of 2,315 − 1319 or 996 Millions cft. to supply the 8 Tanks which will therefore in an average year receive 371·72 + 996 = 1,367·72 Million cft. or 1½ times what is required. —

Supply from upper tanks in a bad year.

29. - In a bad year however no surplus can be expected from the Upper Tanks. —

Evaporation and percolation -

30. — The exact amount of evaporation is impossible to calculate as it depends on area of water spread which last depends partly

on the evaporation it may be taken to be the usual amount allowed in this Province which is 6 ft. per year. This is 1/5 inch per day (during the dry month the evaporation will be more, during the monsoon less) The bund of the Tanks being in good order the percolation may be assumed to 1/7 of the capacity of the reservoir.

It is doubtful if any deduction should be made for percolation as no allowance has been made for rainfall on water spread of reservoirs all of which is effective: taking half area of waterspread 1/4" rain represents 67 Millions cft.—

31.— No allowance is made Corporation &c. on upper tanks.

made for evaporation and percolation in the other Tanks as water will be drawn off from them as soon as it falls below level of weir in Hassarghatta; and though there will of course be a certain amount of evaporation and percolation while the water is being drawn off, this will be more than compensated for by the tail waters of cultivation and leakage from Tanks above

Detailed Calculations taking 3 consecutive years of minimum rainfall.

32 - Assuming that the Tanks are full after North East Monsoon, say on 1st January 1896, and take the worst view of the case that is, that there are 3 years following of 17" rain only and that water

is drawn off for 2,50,000
people at 12½ gallons per
head. -

Water in tank 12th January 96	884·517	Millions cft.
Drawn off at 5,00,000 cft. per day -	182·500	do. —
Evaporation on half area taken Contour 53 & 65	305·483	
Percolation ⅐ Capacity taken — do. —	64·473	
	552·456	
Balance remaining	332·061	
Add received during the year at 8 per cent of rainfall of 17."	95·790	
Total in Reservoir on 1st January 197-	437·851	
Drawn off as above	- 182·500	
Evaporation on half area taken Contours 59 and 50-	202·566	
Percolation ⅐ of do. -	34·446	
	419 512	
Balance ——	18·339	
Add received during the year 8 per cent of 17"	95·79	

Wales

Water in Tank } 114 129
on 1st January/98 }
and this would be
barely a 6 months
supply.

From this it will be seen that taking the worst possible view of the case the water will last 2½ years, but if the reduced supply of 116·8 In. Cft. in the year were taken, the water would last just over 3 years, the balance on 1st January/98 being 145·529 In. Cft.

Detailed calculations taking the 3 worst years on record.

33.— Now taking a rather better case that is with rainfall of the 3 worst years recorded.

Viz: 1875 —— 22"
1876 —— 17"
1877 —— 39"

the percentage run off in the first year may be taken as 10 or 160·86 In. Cft. on 30·41 Sqre. Miles.

Water in Tank 1st January 196 } 884 · 517 cub. ft.

Drawn off — 182 · 5
Evaporation — 305 · 483
Percolation — 64 · 473

532 · 456

Balance — 332 · 061

Received during the year — } 160 · 860

Water in Tank 1st January 197 } 492 · 921

Say — 493

Water in Reservoir 1st January, 97 } 493

Drawn off — 182 · 510
Evaporation — 202 · 566
Percolation — 34 · 446

Total 419 · 512

Balance say — 63 · 488 Cu ft.

Add received during the year 8 per cent } 95 · 790

Water in Tank 1st January 198 } 159 · 278

This supply would last about

about six months or till end of May —

Results arrived at.

34. From these calculations it will be seen that for the large supply required by the Dewan, the Project as worked out in Mr. Scaldwells' report will not give a supply for 3 years taking the 3 worst years on record as a basis, but that with the reduced supply recommended in paras 8 and 9 the catchment and storage are sufficient to ensure a supply for over 3 years even supposing that these will were years with a minimum rainfall of 17". —

Ways in which supply can be increased.

35. — If it is considered that the supply as shown by the foregoing calculations is not sufficient it can be increased in two ways. —

1st

1st. By increasing catchment area.

2nd. By increasing Capacity of Reservoirs.—

36. As it has been shown that in ordinary years the amount available for storage will be 1,367·72 Millions cft. which is more than ample it does not seem ~~necessary~~ useless to increase the catchment area without increasing storage. In bad years increasing the catchment will have little effect.—

Increasing Catchment area.

3rd.—To increase the Capacity of the Hassarghatta Tank that is to raise the weirs more than 15' would not it is thought be safe, so the only alternative is to increase the capacities of the Byatha and Kakal Tanks. So that they with the Hassarghatta will store a 3 years supply—

Increasing Storage

or

or about 1200 Millions of ft.
It was proposed by the Dewan to raise the weirs of the first two Tanks by 6' but this would only give a total storage of 1032.871 and to give a 3 years supply it is probable they would have to be raised 7'.—

Objections to increasing capacities of Byatha and Kakole Tanks.—

38.— The objections to raising the weirs of these Tanks by even 6' are given in Mr. Scaldwell's Report paras 16, 20, 21 and 30 and. from what he says it will be seen that it will be dangerous and expensive to increase the capacity of the Tanks; another objection is the great amount of loss owing to evaporation &c from 3 impounding Reservoirs with the Byatha and Kakole Tanks left

as they are. All the water stored in them will be run into the Hassarghatta reservoir in about 3 months; consequently the loss from evaporation will be trifling; but with the capacity of these Tanks increased to about 500 M. Cft., it will be over 1 year before they empty themselves into the Hassar=ghatta Tank and the evaporation in that time will be enormous. —

How is this [illegible]

39. — There can be no doubt that the storage and catchment counted on in Mr. Scaldwell's report is ample to give an un=failing supply of 10 gallons per head to a population of 200,000 persons and it cannot be too strongly urged that the project be worked out with this supply as the basis more especially

Reduced supply recommended. —

especially as this will cause a considerable saving on several parts of the project. At the end of 10 years when the population has increased to 208,000 it will be time enough to think of increasing the storage but to do so now appears to be a waste of money. One great advantage of this Hassarghatta scheme is, that the total catchment being 211.78 square miles, it is capable of being extended to almost any extent by lowering up tanks and increasing storage

Quality of Supply

Villages on Catchment — 40. — The catchment consists of red soil partly cultivated with dry crops, there are 8 small villages draining into the Hassarghatta Tank, their total population being about 700

the catchment area being about 7 sqre. miles, this represents 100 per sqre. mile, the houses or rather huts in these villages are exceedingly poor and it is thought that if a small amount of compensation per hut were paid and land given outside the catchment there would be no difficulty in getting the people to erect decent ones, at the same time it is believed that the amount of impurity received into the tanks on account of the presence of these few people in the vicinity will be infinitesimally small and it must also be remembered that after leaving the tanks the water will be allowed to settle at two places and also filtered.

41. — As regards the cultivation, it is believed that very little

Cultivation on Catchment.

little if any manure is used and if it is thought that there are objections on sanitary grounds to crops growing in the Catchment the project must be aban= =doned as the cost of buying up 30.41 Sqre Miles would be prohibitive. It is quite hopeless to expect to get a Catchment near Bangalore free from cultivation and habitations and it is not clear why such a condition of things is necessary; if it is necessary all that can be said is, that it would be almost an impossibility to carry out a water Supply Scheme for any large town in this or any other Country. Mr. Caldwell in para 49 of his report has given a quotation from Fanning's treatise on water Supply which is much to the point.

42

42. — addition to the villages named there are and two viz:- Byatha and Kakole draining directly into the tanks of the same name the former consists of 150 houses and 522 inhabitants and the latter 107 houses and 331 inhabitants, these villages are ~~too~~ important to be removed but as the Byatha and Kakole tanks will act as settling reservoirs, it is thought the presence of these villages will not be objectionable. —

43. — Specimens of the water taken from Hassan-ghatta, Byatha and Kakole tanks were sent to the Chemical Examiner and the result of his analysis is as follows: — Analyses of water.

Quality.	Byatha Tank	Ka Kole Tank	Kassar-ghatta tank
Color	faint cloud	White	slightly cloudy
Small	None	slightly earthy	None
Taste	None	None	None
Reaction	Neutral	Neutral	Neutral
Lime	Present	Present	Present
Chlorine	a trace	a trace	a trace
Sulphuric acid	none	none	none
Nitric acid	none	none	none
Ammonia	none	none	minute trace
Sulph. Hydrogn	none	none	none
Magnesia	a trace	trace	—
Total Hardness	25 5 grs of Ca Co3 per gallon	15. 40	19
Permanent	18 5 Ca C Magnesia salts	13. 30	13.6
Removable	7. 0	2. 10	5. 4
Organic matter. Chlorine	Represented as	- -	- -

two specimens from each tanks were examined,

one

one taken from the tank itself and one from the tank cistern and the Chemical Examiner says the two specimens are about precisely the same in each case except that the latter is a little less hard.

The following are his remarks on the waters.

"Hossarghatta tank From the Analysis I consider the water to be a good potable one. it might be a trifle less hard, but the total hardness is nothing like sufficient to render it unfit in any way for drinking

purposes

purposes, it being just a trifle harder than the water in the Kukarhalli Reservoir at Mysore".-

Byatha tank.- "The water from the tank may be said to be a good potable one and quite fit for use".-

Kakole tank.- "This water is by far the best of the three samples" &c.- In conclusion he writes "In the event of these tanks being used as a water-scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably purer than it is at present".-

It

It will be seen from this that the water of all these tanks is good and quite fit for use and that strange to say the water from the Kakole tank close to which there is a village is the best of the three. The Analysis is borne out by the result of inquiries which showed that the people in the villages using the water are healthy.—

Of course it will be necessary to conserve the tanks to the extent of preventing people bathing in the tanks or washing their clothes or cattle in them.

Engineering details and Costs.—

Present condition of Storage Tanks.

44.— The present condition of the Tanks has been described in detail by Mr. Scaldwell in para 10 to 26, it is therefore only necessary to say that the Byatha and Kakole Tanks are in good order and require no additions or improvements and the bund and revetment of the Hassanghatta Tank are very strong the former being from 20 to 5' wide at top.—

Hassanghatta Reservoir.—

45.— The bund of this will be raised 15' the revetment being dismantled and earth thrown in front and a puddle wall built throughout its length. the top width of the bund will be

be 15' front slope 1½ to 1 and rear slope 2 to 1 the revetment will be strongly rebuilt on 1 foot thick of gravel backing. F.S.L. on crest of weir being 281 9"7 top of revetment will be 2825.17 and top of bund 2829.17 that is, 6 and 10 feet respectively above F.S.L.

46.— A bund will be thrown across the Chaund leading to the present escape which is old and leaky and a new escape 300' long will be built on the left flank. The old weir will be repaired as the surplus from the new weir will have to pass over it into the Arkavatti river. (See plan attached) The cost of these works as given

New escape.

given by Mr Caldwell is

Raising bund Rs. 67,394
New weir — 33,541
Repairing old weir 3,615

Total — 104,550

this estimate is believed to be very correct but to allow for contingencies it may be taken to be 110,000 —

Water tower.

47. The position of this is shown on the plan, the design has been worked out in detail but may require some modification but the cost of Rs. 37,663 or say Rs. 38000 may be accepted as correct the total cost of head works will therefore be Rs. 148,000

Delivery Channel.

48. — There was considerable difficulty in

Lattlins

settling the line for this Channel and Mr Scaldwell gives a detailed description of what was finally decided upon but it is possible that a cheaper line may still be found. The Channel is very expensive costing Rs. 149,790 say 150,000 for a length of 23,826 feet or over Rs. 6 per running foot and it may be found that a saving can be effected, but the full amount will be entered in the estimate. The Channel will have a fall of $\frac{1}{5000}$ and will deliver 5.787 cft. a second running 2' deep. HQ. — At the end of the delivery Channel there will be 2 Settling Tanks each

Settling Tanks -

each holding a day's supply from which the water will be pumped, the cost of these two tanks will be Rupees 44,286, say 44,300/ 5%. - These will be fitted up above the settling tank just mentioned the pump will have to lift 5063.6 gallons or 822.174 ft. a minute 3 3/4' high through 1 3/4 mile of 24" internal diameter rising main. Calculations for the lift are given in para 59 of Mr. Caldwell's report these calculations being based on the fact that it is necessary to have the floor of service reservoir at 3055 to command all parts of the station, he has allowed pumping 13½ hours a day with an additional 7 hours twice a week but it would be

c. Pumps and Engines -

be of the full
for 7 days were pumped
up in 6 days of 12 hours
each, that would give
the quantity to be pumped
up as 5063·6, say 5064
Gallons per minute.—
The Agent of the Worthington
Pumping Company, Calcutta
was wired to to ascertain
the cost of suitable pumping
Engines and a reply
was received on the 24th
instant stating inability
to give quotation and
suggesting reference
to Messrs Simpson & Co.
London the latter firm
has been addressed but
as it will be some weeks
before an answer is received
it is not thought advisable
to delay this report on
that account.—
It will be noticed from
para 8 of Major Grant's
report

report dated 25th April 1892, that Head Office received information from the Worthington Pumping Company from which he that pumps and engine to raise 930 gallons per minute to a height of 424 feet through 6 miles of rising main will cost Rs. 115,000. In this case 5,063 gallons have to be raised to a height of 374' through 1.6 miles rising main and it is not thought likely that the cost can exceed the 2 lacs entered in the estimate.—

c. Raising Main.

51.— This will be laid in a straight line from the pumps to a stand post on the top of Banawar Hill, it will be 8,580 feet in length 24" internal diameter and 1" thick and the cost will be

Rs.

Rs. 157588, say Rs. 160000 add Rs. 9,000 for laying and Rs. 1,000 for masonry pillars total cost will be Rs. 170,000/-

52.- The design for the Engine House and Quarters for establishment have to be worked out in detail, the approximate cost of the former will be Rupees 20,000 and of the latter 16,000/-

Engine House &c.

53.- The level of the top of Banawar Hill +3097.64 not being sufficiently high to give the required head over the service reservoir on Muntapam Hill floor of which will be +3055, it is necessary to erect a Stand pipe 42 feet high, this will be combined with a Signal Station, the cost of this will be Rs. 3505, say Rs. 3,500. (If the water has

Stand Pipe.

has to be delivered in 12 hours, the height of Stand pipe 42' as allowed by Mr. Scaldwell will not be sufficient and a height of 70' will be required, the cost will then probably be about Rs. 5000 and the lift will be 385")

Delivery Main -

54. — This will start from the Stand post at Banawar Hill and run in an almost perfectly straight line to the Service Reservoir on the Muntapam Hill the total length will be 36,960 feet, internal diameter 24" and thickness Metal 1" (see Mr. Scaldwell's detailed calculations para 66

It is usual to make 24" pipes 1' thick but it is thought that it would be cheaper to reduce the thickness of metal when the pressure is low and

such

risk chance of breakage in carriage-) The cost at 7/12 per cent will be

Rs. ———	6,73,861
To which must be added laying at Re 1 per foot ———	36,960
5 Air Valves @ Rs 200-	1,000
6 Scour -do- " 150-	900
4 - -do- " 520-	2,080
6 Reflex Valves " 500-	3,000
Total	7,17,801
Say ———	7,20,000

This is a very liberal estimate and it is believed that the cost will not be more than 6½ lacs.—

Filtering Reservoir-

55.— There will be three of these, two of which will give a days supply at the rate of 75 gallons per sqre foot per day. The details have not been accurately worked out, but the cost will be approximately

Rs.

Rs 33,000/-

Second Reservoir — 56:— This will contain 3 days supply, the details have not been accurately worked out the approximate cost will be 121,733, Say 122,000/-

Compensation. — 57. — In para 72 of his report Mr Caldwell gives the compensation to be paid on account of land thrown out of cultivation under the Byatha, Kakole and Hassarghatta Tanks as Rs 50,000 to this must be added approximately another Rs 20,000 for land under the remaining 5 Tanks bringing the total up to Rs 70,000 as this is only approximate and does not include the tanks mentioned in para 21, it will be safe

to

to take Rs 1,00000 as the amount to be paid for compensation. —

Present value of Tanks

58. — This is given in Statement attached to para 27 of Mr Caldwell's report and amounts to Rs. 1,04,795 to this has to be added the value of the 4 small Tanks proposed to be thrown out of cultivation vide para 21 the total value may therefore be taken as 1,20,000/- (This estimate was made up at the request of the Dewan the Mysore Government will not of course have to pay for their own Tanks)

Distribution

59. — This is taken at Rupees 3½ per head and is what has been allowed in other water supply Projects for Civil & Military Station, the total cost allowing 2,50,000 people will be 8,75,000/-

No

No attempt has been made to work out the ~~cost~~ detail of the cost of distribution Rs 3½ per head is what has been allowed in other schemes for the supply of Civil and Military Station but as the City is more compact it is probable the average cost will be less) —

Establishment Tools & Plant.

60. — It will be necessary to allow 2½ per cent on all items representing work in fact on the cost of project less value of tanks compensation, cost of piping, stand post, rising main and delivery pipe, this amounts to Rs 180,000. (This item has not been allowed in any of the projects hitherto prepared except Major Grant's Madigal Project — It seems absurd to suppose that such a large sum will be required for a work that should not last more than 3 years

am

and for which no special machinery or appliances will be required.—

61.— 5 per cent on the total Estimate is allowed on this account.— Contingencies.—

62.— To this a sum of Rs. 72,200 has been entered on this account.— (Not allowed in other projects but advisable.—) Unforeseen Expenses.

Abstract of Estimate.—

63.—

1. Headworks —	1,48,000
2. Delivery Channel —	1,50,000
3. Settling Tanks —	44,300
4. Pumps & Engines	2,00,000
5. Rising main —	1,40,000
6. Engine House —	20,000
7. Quarters for Establt —	16,000
8. Stand Post —	3500
9. Delivery main —	72,0000
10. Filtering Reservoir	33,000
11. Service Reservoir —	1,22,000
12. Compensation —	1,00,000
13. Value of Tank —	12,0000
14. Distribution —	8,75,000
	27,14,800

	27,00,800
Contingencies @ 5 per cent —	1,36,000
Establishment Tools & Plant at 2½ per cent on all items of cost	1,80,000
Add for unforeseen expenses —	12,200
Total	31,00,000

or 31 Lakhs.

General remarks on Estimate.

64.— The estimate is it is believed a very liberal one and there is no chance of it being exceeded, on the contrary a saving can probably be effected on items 2, 5, 9 & 14

Cost per head.

65.— The cost 31 Lacs seems high and this represents a charge of Rs. 12·4 per head of the population to be supplied and about Re 1 per gallon per diem, but this compares favorably with many

other

other Water Supply Projects vide Appendix 7 of Coll. Mullins Report on the Bangalore Water Supply from which it can be seen that in the case of the Inchalkaranje water works the cost per head was 13-6-

In the Jalgaon Water works Rs. 13·9 per head, in the Lahore water works 11·5 per head, and in the Secunderabad water works Rs. 4·4 per gallon. It would be interesting if the cost of other water supply schemes such as Bombay, Poona, Kirkee, &c. could be ascertained for the sake of comparison.

Cost of Scheme with reduced supply recommended.

It

66. If the Schemes for supply=
=ing 200,000 people with
10 gallons a day be adopted,
there will be a considerable
reduction in the cost
of the estimate as follows:-

Head Works- 67- The cost of head works
will then be approximately
Rs. 140,000 owing to reduc=
=tion in size of water tower.

Delivery Channel. 68.— The delivery chan
=nel will cost about Rs.
30,000 less or Rs. 120,000
as it will only have to
discharge 3·7 cft. instead
of 5·7 cft. a second-

Settling Tanks 69.— The settling tanks
will not cost more than
Rs. 30,000 as they need
only contain 2,00,000
gallons instead of 3,125,000
gallons each.—

Pumps & Engines. 70.— The pumps will
have to lift 3240·73 gallons
per

per minute instead of 5063.6 and they will therefore be cheaper and the price may be taken approximately at Rs. 180,000/—

71.— The Stand pipe will cost say Rs. 3,000 against Rs. 3,500. (In this case the stand pipe will have to be 60' high and the lift will be 375.) Stand Pipe.

72.— With the reduced supply the delivery main need only be 20' internal diameter; for a length of 18,282' the head may be taken as 360' the thickness of metal will therefore be 1" for a length of 18,678' the head may be taken as 140' and the thickness of metal will be $\frac{7}{10}$" (Delivery Main.

The weight per foot of 20" pipe 1" thick is 204 lbs per foot, therefore

therefore the weight of 182.82 will be 1,665 tons and at Rs. 150 per ton cost will be Rs. 2,49,750.

The weight per foot of a 20" pipe $\frac{7}{10}$" thick is 142 lbs per foot therefore the weight of 18,678' will be 1184 tons and the cost at Rs. 150 per ton will be Rupees 1,77,600. The total cost of the piping will thus be 4,27,350 to this must be added Rs. 36,960 for laying and Rs. 6,500 for valves making the total cost of the Delivery main 4,70,810 against Rs. 7,20,000/-

Rising Main -

73. — The rising main will be 20" diameter 1" thick and will therefore weigh 204 lbs per foot, the length being 8,580' the total weight will be 781.4 tons and at Rs. 150 a ton cost of pipes will be Rs. 1,17,210 add for laying

Building

building masonry pillars &c= Rs. 9,000, total cost Rupees 1,26,210, say 1,30,000/- against Rs. 1,70,000/-

Filtering Reservoir

74.- The filtering reservoir may be smaller and the cost taken at Rupees 25,000/-

Service Reservoir.

75.- The same amount viz: Rs. 1,22,000 will be left for service reservoir as it is desirable that it should hold more than a 3 days supply.—

Distribution.

76.- Distribution at 3½ per head will be Rs. 76,0000.

Other item.

77.- The other item will remain as before the total cost of the reduced scheme will therefore be as follows.

78.

Abstract of cost of reduced Scheme.

1 Head works		1,40,000
2. Delivery channel		1,20,000
3. Settling tank	—	30,000
4 Pumps and Engines	-	1,80,000
		4,70,000

5. Rising Main — 1,30,000
6 Engine House — 20000
7. Quarters for Establ — 16,000
8. Stand-post — 3,000
9. Delivery Main — 470,000
10. Filtering Reservoir — 25,000
11. Service Reservoir — 1,22,000
12. Compensation — 1,00,000
13. Value of Banks — 1,20,000
14. Distribution — 7,60,000

22,36,000

Contingencies at 5 per cent — 1,11,800

Establishment and Tools & Plant — 1,30,000

24,77,800

Unforeseen expenses say — 47,200

Total — 25,25,000

or 25 1/4 Lacs. —

Results —

79. Thus it will be seen that the present population of Bangalore being 1,80,000 a supply of water at the rate of 10 gallons per head per diem for 2,00,000 people to last through 3 years of a minimum

minimum yearly rain fall of 17" can be secured at a cost of 25¼ lacs and this being the case it does not seem desirable to expend 31 lacs on the larger Scheme.—

80.— Taking 31 lacs the proportion to be paid by the British and ellyssr Government would be respectively 17.33 lacs and 13.77 lacs, and taking 25¼ lacs, the proportion would be 14.03 and 11.22 lacs.— Proportion of cost.

81.— It will be interesting to compare the cost of this project with some others that have been prepared and the following shows the result.— Comparison of Cost with other Projects.

Mr. Carminis Madigal

Scheme Cost — 9,79,75¼

Supply — 668.75 gallo

Cost per 10 gallons Rs. 14.6

Mr. De Mendons Madigal

Scheme Cost — 1,190,000

Supply — 668.750 gallo

Cost per 10 gallons Rs. 17.

Major Grants Madigal

Scheme cost 19,05,050

Supply — 668·750 gallo

Cost per 10 gallons Rs. 28·

Present Scheme cost 31,00,000

Supply —— 31,25,000 gallo

Cost per 10 gallons Rs. 9·9

Reduced present Scheme costs 25,25,000

Supply — 2,000,000 gallo

Cost per 10 gallo Rs. 12·62

So that it will be seen that as regards cost of supply per gallon the present or Nassar-ghatta Project is the cheapest·

Remarks on other water supply Projects of Bangalore·

82.— Numerous Water Supply Projects have been prepared for Bangalore and it is believed they have all been finally rejected except the Hebbal and the Madigal.

Hebbal Scheme·

83.— As it is now proposed to have a joint scheme for the City and Civil & Military Station

Station. Hebbal Tank as a source of supply may be put out of the question as the free Catchment area is only 4½ Sqre Miles and the total 12½ Sqre Miles and the supply would be quite insufficient even supposing all the Tanks in the Series were brought up.—

Madigal or Marigal Scheme.

8th.— Major Grant has lately investigated the Madigal Scheme and estimates the cost at 19,05,050.

The objections to this Scheme are:—

1st. The Catchment area though a very excellent one both as regards purity and run off is only 10 Sqre Miles and this would be quite insufficient to give a yearly supply of 182.500 or even the reduced supply

of

of 116·8 million cft during
bad years.—

The supply could per-
haps be increased by
making long and expensive
Contour Channels into other
Valleys; but even if this
were done the storage would
be a difficult matter as
several dams would be
required and it is doubtful
if sites for them can be
found, and more over
these Contour Channels
would drain very highly
cultivated land and thus
do away with any advantage
the Madigal Scheme has
over the Nassanghatta
as regards purity of
Catchment. All things
considered it may safely
be asserted that, for a
joint Water Supply Scheme
the Nassanghatta possesses
advantages superior

to

to all others.—

85.— It has been suggested that the Hebbal Tank might be used to supply the Civil and Military Station and the Madigal Valley the City, but even supposing the supply to be sufficient, the united Cost would be more than that of the Hossarghatta as follows:—

Hebbal and Madigal combined.

Cost of Hebbal Scheme vide General Fischer's report and Coll. Bowen's note thereon.

Rupees	3,00,000
Valley tanks	1,50,000
Add Compensation	2,00,000
Distribution	5,25,000
Establishment and Tools & Plant	25,000
Contingencies	59,000
Total	12.59,000

(this estimate is only approximate and is probable below the mark.—)

Cost of Madigal Scheme

as

as estimated by Major Grant Rs. 19,05,050

Total cost of the two Schemes Rs. } 31.64.000

against Rs. 31 or 25½ lacs and it must be remembered that the Hassarghutta Scheme supplies 12½ & 10 gallons per head for natives while the other Schemes only allow 6½. It must also be remembered that the working expenses of two Schemes will be double or more than double that of one. —

Working Expenses.

86. — It will now be necessary to consider the working expenses first taking the larger estimate of 31 lacs. —

Interest on Capital.

87. — Interest at 4 per cent } = 124.000

9/10

88.— The yearly loss of Revenue under the Byatha Kakole and Hassarghatta Tanks will be Rs. 3,148 it is regretting that accurate information cannot be given with regard to the other Tanks as it has not been received from the Revenue Authorities but as they are all small it is thought that the total loss cannot exceed 5,000-

Loss of Revenue on taken up

89.—

Establishment-

1. Overseer to Superintendent the Complete system on Rs. 60 = 720

1. Reservoir Superintendent and 3 Peons at Hassarghatta to regulate the Supply and watch the Tanks-

Superintendent Rs. 20 per month = Rs. 240

3 Peons Rs. 18 = Rs. 216

2 Watchmen on
Banawar Hill
at Rs 6 = Rs 144

2. Engine Drivers
at Rs 20 —— 480

2. Stokers @ Rs 7 —— 168

2. Coolies @ Rs 6 —— 144

Total Establt 2,112

Depreciation. — 90. —

Depreciation of Machinery
7 per cent on
2 lacs (2,00,000) = 14,000

Depreciation of Pipes,
valves &c @ 4 per cent
on 7,00,000 —— 28,000

Fuel and Lunall
Stores — 2,0000

Repairs. — 91. — Repairs at 1 per cent — 3,000

Total. 92. — The total working
expenses will
therefore be 2,24,112

say — 2,25,000

or 4 annas 14·5 per head of
population taken as
25,00,000.

Q3.— Taking the smaller estimate of 25¼ lacs the working expenses work out as 1,86,000/-
or about Ans. 14·8 per head for a population of 1,00,000

Taking expenses in Scheme.

Q4.— This does not appear to be by any means an exorbitant taxation to impose for a good water supply and what is really amounts to is that each person will receive 2190 chatties holding 2 gallons each of pure water a year at a cost of 1/130 of an anna per chatty or that is will receive delivered almost at his door 130 chatties or about a 2.6 days supply for one anna.—

General remarks on cost of working expenses.—

Q5.— In case an unfavored comparison may be made as regards the working expenses of this project as compared with

Interest on capital.

with those of others it may be mentioned that it is believed that in no other case has the interest on capital been added and this is a large item.

Concluding Remarks.

96.– In conclusion it is requested that it may be borne in mind that this is only a preliminary report submitted with the object of enabling it to be decided at an early date whether the project should be investigated in detail or not.–

Accuracy of estimates.

97. Mr. Sealdwell has worked out the cost of the different items with great care and in considerable detail, but the figures cannot be accepted as absolutely correct, though it is believed that the total will be within a few thousand £ pos

of the correct amount
and that any errors
there are will be on the
right side.——

Fdr. Campbell
Lt Col: R E
Chief Engineer Mysore
Bangalore
26th Jany 1893

PRELIMIANRY REPORT ON THE PROJECT FOR SUPPLYING THE CIVIL AND MILITARY STATION AND CITY OF BANGALORE FROM THE HESSARGHATTA RESERVOIR.

INTRODUCTORY REMARKS.

1. *The Arkavati River.*—Amongst the voluminous papers connected with the Bangalore Water-supply, the proposal to utilise the waters of the Arkavati river is several times mentioned, the idea being apparently to dam up the river and pump up the water through pipes, but no details were worked out: the proposal to take water from the Hessarghatta Tank situated on that river (Latitude 13° 9′, Longitude 77° 31¾′, see map attached to report) is also referred to but seems to have been abandoned on the score of distance and lift.

2. *Previous investigations.*—The subject of the water-supply has been investigated by several officers and their investigations show clearly that it is absolutely impossible to get a sufficient supply for even the Civil and Military Station alone by gravitation and that pumping must be resorted to.

3. *Existing large catchments.*—It is also shown clearly that to get an unfailing supply in a year of deficient rain-fall the catchment area must be of considerable extent and the only such catchments are that of the Penakini river to the east, and that of the Arkavati river to the west of Bangalore.

4. *Increasing existing catchments.*—Projects have been prepared or proposed for getting large catchment areas nearer Bangalore by means of long contour channels extending to several different water sheds and by buying up series of tanks, but none of them are by any means satisfactory and the two catchments mentioned above are the only ones from which an almost unfailing supply can be obtained; an absolutely unfailing supply is of course an impossibility as with no rain or nearly none, there would be no water, whatever scheme were adopted.

5. *Arkavati and Penakini catchments.*—As regards the two sources of supply, the Arkavati is by far the most satisfactory as it is nearer, higher and contains better water and therefore the Penakini need not be considered.

6. *Dam across Arkavati River.*—To build a dam across the Arkavati river below the Hessarghatta Tank as was proposed by Colonel Vibart, R. E., would be waste of money as the bund of that Tank already forms a dam across the river at a higher level and only wants raising slightly to answer all requirements and it has consequently been settled to use the Hessarghatta Tank as the reservoir of supply.

7. *Instructions given by the Dewan.*—The idea of investigating the Hessarghatta scheme originated with the present Dewan Sir K. Sheshadri Iyer and he wrote a memo of instructions, dated 31st October 1892, giving data on which the investigations were to be made. these were.—

1*st.* The scheme to allow for a population of 250,000 people.

2*nd.* The supply to be 2 c ft or 12½ gallons per head per day.

3*rd.* The reservoir to contain a supply for 3 years.

8. *Remarks on the Dewan's instructions—population.*—As regards No 1, the population in 1881 was 155,857 and in 1891, 180,366, showing an increase of 24,509 or 157·2 per 1,000, so that in 1901, the population will be 208,740 and in 1911, it will be 241,637, therefore in 20 years the figures laid down by the Dewan will not be reached and though it is advisable to allow for 10 years' increase as it is believed is done in all Water-supply Projects, it does not seem right to tax one generation for the water to be supplied to a future one. It is therefore considered that the supply should be limited to that required for a population of 200,000.

9. *Supply.*—As regards No. 2 data, the supply to be given per head per diem depends on whether the scheme is to be complete in itself or whether it is to supplement the supply received from wells and other sources; in the former case, 12½ gallons is none too great but in the latter 10 gallons per head ought to suffice; and as there is no doubt that a good part of the population will still resort to wells, it is thought that only 10 gallons per head should be allowed, and it must be remembered that in most of the water-supply schemes hitherto prepared for Bangalore, the supply for the Native population of the town has been taken at only 6¼ gallons and this should be considered in comparing the cost of this with other projects. It will be well here to quote from the Memo of Colonel Hasted, Chief Engineer, Madras, on the Bangalore Water-supply, in para 6 of which he writes,—"It will be well here to consider the quantity per head per diem that should be provided. In the schemes that have been proposed, this quantity varies very considerably, the highest being 20 gallons and the lowest for drinking purposes alone about 2 gallons. The ordinary allowance in England in non-manufacturing towns is 16 to 20 gallons, but in this country where water is not required for closets or for washing clothes, it may be very much less" Major Kensington says—"In Mysore according to very carefully prepared statistics, the consumption was found to be in 1874, 1¼ gallons a head per diem at the highest estimate. Surgeon E. Nicholson who was for a long time employed as Analyst of waters in Mysore in his report, dated 13th December 1871, on the water-supply of Bangalore, puts down 3 gallons a head per diem for every man, woman and child as very liberal The supply provided for the troops in Captain Romilly's estimates, the latest approved by Government, was about 12 gallons per head per diem, and it is considered that a very ample supply will be provided if 2 c. ft. or 12½ gallons are allowed for the troops and 1 c. ft. or 6¼ gallons for the Native population."

10. *Storage.*—As regards the 3rd data, it is not very clear if the Dewan meant that the reservoir was to contain a three years' supply independent of rain falling during that time and including evaporation and absorption, if so, the capacity of the reservoir will have to be enormous (about 1,100 millons c. ft.) and it is considered if it be large enough to contain a 2 years' supply of 10 gallons per head for a population of 200,000 people including evaporation and absorption and assuming that all of these years will be years of the lowest known rain-fall, it will be all that is required.

11. *Mr. Scaldwell's report.*—In accordance with the Dewan's Memo, Mr. Scaldwell, Executive Engineer, Bangalore Division, was ordered on the 2nd November 1892, to prepare a preliminary report on the Hessarghatta Water-supply scheme; and this report which he has prepared with great care was submitted on the 10th January 1893.

12. *Storage allowed by Mr. Scaldwell.*—The supply allowed by Mr. Scaldwell is as laid down by the Dewan, that is, 12½ gallons per head for 250,000 persons or 500,000 c. ft. per day equal to 182·5 millions of c. ft. per annum: but he only allows a storage capacity in the Hessarghatta and other tanks above (to be described hereafter) of 870·22 millions c. ft, which would be about ¼ that required by the Dewan, *vide* para 10.

13. *Storage required for 200,000 persons at 10 gallons per head.*—Supposing 200,000 people were to be supplied at the rate of 10 gallons (1·6 c.ft. per head per-day,) this will require 320,000 c.ft. a day or 116 8 millions c. ft. per year; and the capacity allowed by Mr. Scaldwell would be more than two years' supply without any rain-fall being added.

14. *Mr. Scaldwell's figures adopted in this report.*—In this report Mr. Scaldwell's figures will be adopted, but it will be shown what the results would be if the smaller ones were taken.

BRIEF DESCRIPTION OF PROJECT.

15. *Tanks included in project.*—It is proposed to buy up the 8 lowest tanks of the Hessarghatta series, these are (*vide* Topo. map herewith)—

Hessarghatta.	Chik Devenpur.
Byatha.	Tumbinakere.
Kakol.	Arasinakunte.
Sonnenhalli.	Dyavarakunte.

All these will be left as at present with the exception of the first named (the terminal tank), which will have its weir raised by 15

16. *Delivery.*—In three of these tanks 870·22 millions of c. ft. of water will be impounded, and from the Hessarghatta Tank the supply required for the town will be drawn off and carried 23,826 ft. in a masonry channel to a settling reservoir near Banawar hill, from whence it will be pumped to a stand-pipe 42 ft. high on the top of that hill (level 3,087·64) and from this stand-pipe the water will be delivered by gravitation through a 24″ cast iron main to a service reservoir and filter on Shantapam hill, from whence the distribution to the Civil and Military Station and the City will be taken off.

17. *General remarks on project.*—The Project is a simple one in an engineering point of view; the chief points to be considered and discussed before the details are worked out being—

1. Quantity and storage of water available.
2. Quality of water.
3. Cost of Project.

It has been proposed to build the service reservoir at a lower level, the water required for the higher parts of the station being pumped up separately, the average level of the Petta may be taken at under 2,970′ and therefore a reservoir with floor at 2,980 would suffice; but there are many parts of Bangalore above this level, such as the Railway Station and the houses in the vicinity, the Residency, the Palace, the Jail, the Government Buildings, houses in the neighbourhood of St. Marks and St. Andrews Churches, and the High Ground, and a large volume of water would have to be separately pumped and this is not thought advisable owing to the cost.

To command the high parts of Bangalore mentioned, omitting only the High Ground and Railway Station, a service reservoir floor about 3,025 would be required, and it is thought better to pump the extra 30′ once for all than to have separate arrangements.

QUANTITY OF WATER AVAILABLE.

18 *Present and proposed capacity of Tanks.*—In para 6 to para 28 of his report, Mr. Scaldwell has described in detail the present condition of the 8 tanks to be taken up, so it is sufficient here to state that the total capacity of all these tanks is at present 206·736 millions of c ft., and with the weir of Hessarghatta raised 15′ the capacity will be 884·517 millions c. ft., but the 5 tanks named last in para 15 may be omitted as they are very small and shallow, the total capacity will therefore be 870·22 or say 870 millions of c. ft., which excluding evaporation and absorption is more than the 3 years' supply of 547·5 millions of c. ft. laid down by the Dewan, and would be more than 3 years of the reduced supply recommended in para 10, evaporation and percolation being *included*

19. *Catchment area.*—The total catchment area of the Hessarghatta Tank and the 183 tanks above it is 211·78 square miles, and the free catchment of the 8 tanks to be taken up is 22·78 square miles

20. *Extra catchment.*—In addition to this, there is a catchment of 8·85 square miles, *vide* Statement C, attached to Mr. Scaldwell's report, that is free to the extent of $\frac{2}{3}$ of the run-off during ordinary years and $\frac{1}{2}$ during years of minimum rainfall, the capacity of the tanks in that area being so small, that even in the worst years not more than half the run-off can be impounded, therefore 1·42 square miles may be added to the 22·78, giving a total of 27·20.

21. *Additional catchment proposed.*—An additional area of 3·21 square miles may be obtained by throwing out of cultivation the four very unimportant tanks mentioned in Mr. Scaldwell's Statement D. This would bring the total free catchment to 30·41. As these tanks can be bought for very little, it is adivisable that this be done.

22. *Rain-fall.*—No reliable rain-fall registers have been kept at any stations in the Hessarghatta catchment. Mr. Scaldwell submits statements of the rain-fall for the last 3 years at Nelamangala Dodballapur and Yelahanka, but these cannot be depended upon, therefore the figures for Bangalore must be accepted, though judging from the geographical position, it is probable that the rain-fall is greater in the Arkavati valley, and this opinion is borne out by those who have had many years' acquaintance with this valley. The average yearly rain-fall at Bangalore may be taken at 35″, the minimum at 17″ and the maximum at 56″.

23. *Run-off from catchment.*—What amount of run-off can be counted on is always a doubtful point, as it depends on the nature of the rain-fall; with a yearly total of 40″ if the rain fell in small showers at considerable intervals, the run-off might be less than with a yearly total of 20″ in which there were two or three heavy downpours. (The percentage of run-off also diminishes with the increase of catchment area.)

24. *Run-off from catchment of Sankey's Tank.*—From the records of Sankey's Tank, the average run-off is about 14 per cent of the rain-fall, while the least is apparently 9 per cent; but there appears to be some error about this last figure, or else it is due to the catchment Channels being out of order, for this small percentage was received in 1888-1890 when the rain-fall was 31·12″ and 34·37″ respectively, while in 1884 when the rain-fall was only 21·67″ the amount received into the Tank was 17 per cent.

Assumed run off from the catchment of Sankey's Tank probably incorrect.

25. It has generally been assumed that in the case of Sankey's Tank the amount of run off from 1 square mile of catchment is, 7 millions c. ft. in a bad year, 11 millions c. ft. in an average year and 17 millions c. ft. in a good year, (Vide para 4 of Chief Engineer Colonel Hasted's note on Bangalore Water-supply, dated 14th July 1888, and Colonel Bowen's note on General Fisher's Hebbal Scheme) and these figures have been adopted by Mr. Scaldwell in calculating the run-off at Hessarghatta. But they are apparently incorrect, as they mean that in a year of 17 of rain the run-off would be about 18 per cent. in a year of 35," about 14 per cent, and in a year of 56″ about 12 per cent, and this is quite contrary to what is known to be a fact, *viz.*, that as a rule the percentage of run-off is less, the less the rain-fall

Run-off assumed in other projects and amount allowed in this one.

26. In many of the water-supply schemes that have been prepared, the run-off has been taken at 13 per cent of the rain-fall in a bad year, and this amount is calculated on both by Mr. Standish Lee and Major Grant, R. E., in the Maligal Project, and taking the nature of the Maligal catchment into account, this figure is probably not too high, but in the case of the Hessarghatta catchment, which is partly cultivated and not steep, 8 per cent is perhaps as much as should safely be allowed in a year of a minimum rain-fall of 17″: this will give a run-off of 3·15 millions c. ft. per square mile

Run-off laid down by Major Kensington from tanks catchments generally and amount calculated on in this project.

27. The late Major Kensington, R. E., who was intimately acquainted with the tanks in the Province, has laid down that the run-off in ordinary years from a catchment similar to that of the Hessarghatta, and which he describes as follows –

" Red or black soil, porous, cultivated, or scrub jungle, or grass, catchment flat" is 20 per cent " So it will be safe to take 15 per cent or 12½ millions, say 12 millions as the run-off from 1 square mile. Therefore, during an average year of 35″ rain-fall, the total run-off from the 30·41 square miles will be 371·72 millions c. ft. and only 95 79 millions in a year of 17″ fall. The run-off from Sankey's catchment in 92 was 11 millions c. ft. per square mile, rain-fall being 27."

Run off from Kakol Tank catchment, see Mr. Scaldwell's Table F., was also 11 millions c. ft. a square mile, with rain-fall below the average and these are both far in excess of the run off allowed in the calculations in this report.

Supply from upper tanks in an average year.

28. As the capacity of the 8 tanks included in the project is 884 millions of c. ft., *vide* para 18, it follows that in an average year, the supply will not fill them, but it will be seen from Mr. Scaldwell's Table B., the capacity of the other upper tanks in the Hessarghatta series is 5,075 units or 1,319 millions c. ft. and the catchment area being 189 square miles, the run off would be 2,315 millons of c. ft. which would fill all the tanks and leave a surplus of 2,315—1,319 or 996 millions c. ft. to supply the 8 tanks, which will therefore in an average year receive 371·72 + 996 =1,367·72 millions c. ft or 1½ times what is required.

Supply from upper tanks in a bad year.

29. In a bad year however, no surplus can be expected from the upper tanks

Evaporation and percolation.

30. The exact amount of evaporation is impossible to calculate, as it depends on area of water-spread which last depends partly on the evaporation; it may be taken to be the usual amount allowed in this Province which is 6 feet per year. This is $\frac{1}{60}$" per day. (during the dry month the evaporation will be more, during the monsoons less). The bund of the tank being in good order. the percolation may be assumed to $\frac{1}{7}$th of the capacity of the reservoir. (It is doubtful however if any deduction should be made for percolation as no allowance has been made for rain-fall on water-spread of reservoirs, all of which is effective taking half area of water-spread 17' rain represents 67 millions c. ft.)

Evaporation, &c, and upper tanks.

31. No allowance is made for evaporation and percolation in the other tanks as water will be drawn off from them as soon as it falls below level of weir in the Hessarghatta, and though there will of course be a certain amount of evaporation and percolation, while the water is being drawn off, this will be more than compensated for, by the tail water of cultivation and leakage from tanks above.

Detailed calculations taking 3 consecutive years of minimum rain-fall.

32. Assuming that the tanks are full after north-east monsoon, say on 1st January 1896, and taking the worst view of this case, that is. that there are 3 years following of 17" rain only and that water is drawn off for 250,000 people at 12½ gallons per head:—

Water in tank, 1st January 1896 ..	...	884 517	Millions c ft.
Drawn off at 500,000 c ft. per day ..		182 500	Do.
Evaporation on half area taken contour 53 & 65		305 483	
Percolation 1th capacity taken do ...		64·473	
			25456
Balance remaining . ..	...	332 061	
Add received during the year at 8 per cent of rain fall of 17		95 790	
Total in reservoir on 1st January 1897 ...	.	437·851	
Drawn off as above	...	182 500	
Evaporation on half area taken contours 59 and 50 ..		202 566	
Percolation th of do ..	.	34 446	
			419 512
Balance	...	18·339	
Add received during the year 8 per cent of 17' ..		95 79	
Water in tank on 1st January 1898		114 19	

And this would be barely a 6 months supply

From this it will be seen that taking the worst possible view of the case the water will last 3 years, but if the reduced supply of 116 8 millions c ft in the year were taken the water would last just over 3 years, the balance on 1st January 1895 being 245 523 millions c. ft

33. *Detailed calculation taking the 3 worst years on record.*—Now taking a rather better case, that is, with rain-fall of the 3 worst years recorded, *viz*:—

1875	...	...	22″
1876	...	...	17″
1877	...	...	39″

the percentage of run off in the first year may be taken as 10 or 160·86 millions c. ft. on 30·41 square miles.

Water in tank, 1st January 1896	..	...	884 517	Millions c. ft.
Drawn off	...	...	182·5	
Evaporation	...	..	305·483	
Percolation	...	...	64·473	
		Total.....	552 456	
Balance	...	...	332·061	
Received during the year	...	...	160 860	
Water in tank, 1st January 1897	..	...	492 921	
Say	..	...	493	
Water in reservoir, 1st January 1897		...	493	
Drawn off	..	...	182·510	
Evaporation	..	...	202 566	
Percolation	.	...	34·446	
		Total.....	419·512	
Balance say		...	63 488	Millions c. ft
Add received during the year 8 per cent of 17′		...	95·79	
Water in tank, 1st January 1898 ...		...	159·278	

This supply would last about six months or till end of May.

34. *Result arrived at.*—From these calculations it will be seen that for the large supply required by the Dewan the project as worked out in Mr. Scaldwell's report will not give a supply for 3 years taking the 3 worst years on record as a basis, but that with the reduced supply recommended in paras 8 and 9, the catchment and storage are sufficient to ensure a supply for over 3 years, even supposing that these were years with a minimum rain-fall of 17″.

35. *Ways in which supply can be increased.*—If it is considered that the supply as shown by the foregoing calculations is not sufficient, it can be increased in two ways.—

1st. By increasing catchment area.

2nd. By increasing capacity of reservoirs.

36. *Increasing catchment area.*—As it has been shown that in ordinary years the amount available for storage will be 1367·72 millions c. ft. which is more than ample, it does seem useless to increase the catchment area without increasing storage. In bad years increasing the catchment will have little effect.

37. *Increasing storage.*—To increase the capacity of the Hessarghatta Tank, that is to raise the weirs more than 15′ would not it is thought be safe; so the only alternative is to increase the capacities of the Byata and Kakol Tanks, so that they with the Hessarghatta will store a 3 years' supply or about 1,200 millions c ft. It was proposed by the Dewan to raise the weirs of the first two tanks by 6′ but this would only give a total storage of 818·145 and to give a 3 years' supply it is probable they would have to be raised 7′.

38. *Objections to increasing capacities of Byata and Kakol Tanks.*—The objections to raising the weirs of these tanks by even 6 are given in Mr. Scaldwell's report, paras 16, 20. 21 and 30, and from what he says it will be seen that it will be dangerous and expensive to increase the capacity of the tanks. Another objection is the great amount of loss owing to evaporation, &c., from 3 impounding reservoirs: with the Byata and Kakol Tanks left as they are, all the water stored in them will be run into the Hessarghatta reservoir in about 3 months, consequently the loss from evaporation will be trifling; but with the capacity of these tanks increased to about 500 millions c. ft., it will be over 1 year before they empty themselves with the Hessarghatta Tank and the evaporation in that time will be enormous.

39. *Reduced supply recommended.*—There can be no doubt that the storage and catchment counted on in Mr. Scaldwell's report is ample to give an unfailing supply of 10 gallons per head to a population of 200,000 persons, and it cannot be too strongly urged that the project be worked out with this supply as the basis, more especially as this will cause a considerable saving on several parts of the project. At the end of 10 years when the population has increased to 208,000, it will be time enough to think of increasing the storage, but to do so now appears to be a waste of money. One great advantage of this Hessarghatta scheme is that the total catchment being 211·78 square miles, it is capable of being extended to almost any extent by buying up tanks and increasing storage.

QUALITY OF SUPPLY.

40. *Villages on catchment.*—The catchment consists of red soil partly cultivated with dry crops; there are 8 small villages draining into the Hessarghatta Tank, their total population being about 700, the catchment area being about 7 square miles; this represents 100 per square mile, the houses or rather huts in these villages are exceedingly poor and it is thought that if a small amount of compensation per hut were paid and land given outside the catchment, there would be no difficulty in getting the people to settle elsewhere, at the same time it is believed that the amount of impurity received into the tank on account of the presence of these few people in the vicinity will be infinitesimal and it must also be remembered that after leaving the tank the water will be allowed to settle at two places and also filtered.

41. *Cultivation on catchment.*—As regards the cultivation, it is believed that very little if any manure is used, and if it is thought that there are objections on sanitary grounds to crops growing in the catchment, the project must be abandoned as the cost of buying up 30·41 square miles would be prohibitive It is quite hopeless to expect to get a catchment near Bangalore free from cultivation and habitations and it is not clear why such a condition of things is necessary; if it is necessary all that can be said is that it would be almost an impossibility to carry out a Water-supply Scheme for any large town in this or any other country. Mr. Scaldwell in para 49 of his report has given a quotation from Fanning's treatise on water-supply which is much to the point.

42. *Villages of Byata and Kakol.*—In addition to the villages named, there are two, *viz.*, Byata and Kakol draining directly into the tanks of the same name; the former consists of 150 houses and 522 inhabitants and the latter 107 houses and 331 inhabitants: these villages are too important to be removed but as the Byata and Kakol Tanks will act as settling reservoirs, it is thought the presence of these villages will not be objectionable.

43. *Analysis of Water.*—Specimens of the water taken from Hessarghatta, Byata and Kakol Tanks were sent to the Chemical Examiner and the result of his analysis is as follows:—

Quality.	Byata Tank	Kakol Tank.	Hessarghatta Tank
Color ...	Faint cloud ..	White ...	... Slightly cloudy.
Smell ..	.. None ...	.. Slightly earthy	.. None.
Taste ...	None .	.. None ...	.. None
Reaction ...	.. Neutral ..	.. Neutral ...	.. Neutral
Lime ...	.. Present ..	.. Present ...	.. Present.
Chlorine ..	.. A trace ..	.. A trace ...	.. Trace.
Sulphuric acid	.. None ..	.. None ...	... None.
Nitric acid ...	.. None .	None ...	.. None
Ammonia ...	.. None ...	. None ...	.. Trace.
Sulphuric Hyd	.. None ...	.. None	.. None.
Magnesia ...	. A Trace ..	.. Trace ...	.. ...
Total Hardness . ..	25 5 grs of Ca^{c}_{3} per gallon ..	. 15 40 grs. of Ca^{c}_{3} per gallon ..	19 grs of carbonate of lime per gallon
Permanent ...	18 5 Ca Cl 1. magnesia salts ...	. 13 30 Ca Cl and magnesia salts	13 6 Chloride of Calcium mainly.
Removeable'	7 0 ..	2 10	5 4
Organic Matter Chlorine	Represented as ..	..	..

Two specimens from each tank were examined, one taken from the tank itself and one from the tank cistern, and the Chemical Examiner says the two specimens are almost precisely the same in each case, except that the latter is a little less hard. The following are his remarks on the water :—

Hessarghatta Tank.—" From the analysis I consider the water to be a good potable one ; it might be a trifle less hard, but the total hardness is nothing like sufficient to render it unfit in any way for drinking purposes, it being just a trifle harder than the water in the Kukarhalli Reservoir at Mysore."

Byata Tank.—" The water from the tank may be said to be a good potable one and quite fit for use."

Kakol Tank.—" This water is by far the best of the three samples."

In conclusion he writes " In the event of these tanks being used as water scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably purer than it is at present."

It will be seen from this that the water of all these tanks is good and quite fit for use and that strange to say the water from the Kakol Tank close to which there is a village, is the best of the three.

The analysis is borne out by the result of inquiries which showed that the people in the villages using the water were healthy.

Of course it will be necessary to conserve the tanks to the extent of preventing people bathing or washing their clothes or cattle in them.

ENGINEERING DETAILS AND COST.

44. *Present Condition of Storage Tanks.*—The present condition of the tanks has been described in detail by Mr. Scaldwell in para 10 to 26. It is therefore only necessary to say that the Byata and Kakol Tanks are in good order and require no additions or improvements and the bund and revetment of the Hessarghatta Tank are very strong, the former being from 20 to 57′ wide at top.

45. *Hessarghatta Reservoir.*—The bund of this will be raised 15′, the revetment being dismantled and earth thrown in front and a puddle wall built throughout its length ; the top width of the bund will be 15′, front slope 1½ to 1, and rear slope 2 to 1, the revetment will be strongly rebuilt on 1 ft. thick of gravel backing. F. S. L. or crest of weir being 2,819·17, top of revetment will be 2,825·17 and top of bund 2,829·17, that is, 6 and 10 ft. respectively above F. S. L.

46. *New Escape.*—A bund will be thrown across the channel leading to the present escape which is old and leaky and a new escape 300′ long will be built on the left flank. The old weir will be repaired as the surplus from the new weir will have to pass over it into the Arkavati River. The cost of these works as given by Mr. Scaldwell is—

	Rs.
Raising bund	66,069
New weir	33,543
Repairing old weir	2,020
Total Rs.....	1,01,632

this estimate is believed to be very correct, but to allow for contingencies it may be taken to be as Rs. 1,10,000.

47. *Water tower.*—The position of this is shown on the plan, the design has been worked out in detail but may require some modification, but the cost Rs. 37,760 or say 38,000 may be accepted as correct ; the total cost of head works will therefore be Rs. 1,48,000.

48. *Delivery Channel.*—There was considerable difficulty in settling the line for this channel and Mr. Scaldwell gives a detailed description of what was finally decided upon, but it is possible that a cheaper line may still be found.

The channel is very expensive costing Rs. 1,49,790, say 1,50,000 for a length of 23,826 feet or over Rs. 6 per running foot, and it may be found that a saving can be effected, but the full amount will be entered in the estimate. The channel will have a fall of $\frac{1}{5,000}$ and will deliver 5·787 cubic feet a second running 2′ deep.

49. *Settling Tanks.*—At the end of the delivery channel, there will be 2 Settling Tanks, each holding a day's supply, from which the water will be pumped : the cost of these two tanks will be Rs. 44,286, say Rs. 44,300.

50. *Pumps and Engines.*—These will be fitted up above the Settling Tank just mentioned. The pump will have to lift 5,063·6 gallons or 822·17 cubic feet a minute, 374 feet high through 1¼ mile of 24″ internal diameter rising main; calculations for the lift are given in para 59 of Mr. Scaldwell's report, these calculations being based on the fact that it is necessary to have the floor of service reservoir at 3,055 to command all parts of the station. He has allowed pumping 13½ hours a day with an additional 7 hours twice a week ; but it would be better if the full supply for 7 days were pumped up in 6 days of 12 hours each, that would give the quantity to be pumped up as 5,063·6, say 5,064 gallons per minute. The Agent of the Worthington Pumping Company, Calcutta, was wired to, to ascertain the cost of suitable pumping engines and a reply was received on the 24th instant, stating inability to give quotation and suggesting a reference to Messrs. Simpson and Co., London. This latter firm has been addressed ; but as it will be some weeks before an answer is received, it is not thought advisible to delay this report on that account. It will be noticed from para 81 of Major Grant's report dated 25th April 1892, that that officer received information from the Worthington Pumping Company, from which he estimates that pumps and engines to raise 930 gallons per minute to a height of 424 feet through 6 miles of rising main, will cost Rs. 1,15,000. In this case 5,063 gallons have to be raised to a height of 374′ through 1·6 miles rising main and it is not thought likely that the cost can exceed the 2 lakhs entered in the estimate.

51. *Rising Main.*—This will be laid in a straight line from the pumps to a stand-pipe on the top of Banawar Hill : it will be 8,580 feet in length, 24″ internal diameter and 1″ thick, and the cost will be Rs 1,57,588, say Rs. 1,60,000. Add Rs 9,000 for laying and Rs. 1,000 for masonry pillars. Total cost will be Rs. 1,70,000.

52. *Engine House, &c.*—The design for the Engine House and Quarters for establishment have to be worked out in detail ; the approximate cost of the former will be Rs. 20,000 and of the latter 16,000.

53. *Stand-pipe.*—The level of the top of Banawar Hill +3,097·64 not being sufficiently high to give the required head over the service reservior on Mantapam Hill, floor of which will be +3,055, it is necessary to erect a stand-pipe 42 feet high ; this will be combined with a signal station. The cost of this will be Rs. 3,505, say Rs. 3,500. (If the water has to be delivered in 72 hours, the height of stand-pipe 42′ as allowed by Mr. Scaldwell will not be sufficient, and a height of 70′ will be required the cost will then probably be about Rs 5,000 and the lift will be 385′)

54. *Delivery Main.*—This will start from the stand-pipe at Banawar Hill and run in an almost perfectly straight line to the service reservoir on the Mantapam Hill ; the total length will be 36,960 feet, internal diameter 24″ and thickness metal 1″. (See Mr. Scaldwell's detailed calculations, para 66) It is usual to make 24″ pipes 1″ thick, but it is thought that it would be cheaper to reduce the thickness of metal when the pressure is low and risk chance of breakage in carriage.

	Rs
The cost at Rs 7¾ per cwt will be...	... 6,78,861
To which must be added laying at rupee 1 per foot ..	... 36,960
5 Air Valves at Rs. 200	... 1,000
6 Scour do „ 150	.. 900
4 Do do „ 520	... 2,080
6 Reflux Valves at „ 500	... 3,000
Total	7,22,801
Say	7 23,000

This is a very liberal estimate and it is believed that the cost will not be more than 6½ lakhs.

55. *Filtering Reservoir.*—There will be three of these, two of which will give a day's supply at the rate of 75 gallons per square foot per day. The details have not been accurately worked out, but the cost will be approximately Rs. 34,000.

56. *Service Reservoir.*—This will contain 3 days' supply; the details have not been accurately worked out, the approximate cost will be Rs. 1,21,733, say Rs. 1,22,000.

57. *Compensation.*—In para 72 of his report, Mr. Scaldwell gives the compensation to be paid on account of land thrown out of cultivation under the Byata, Kakol and Hessarghatta Tanks as Rs. 55,000; to this must be added approximately another Rs. 20,000 for land under the remaining 5 tanks, bringing the total up to Rs. 70,000, as this is only approximate and does not include the tanks mentioned in para 21, it will be safe to take Rs. 1,00,000 as the amount to be paid for compensation.

58. *Present value of Tanks.*—This is given in statement attached to para 27 of Mr. Scaldwell's report and amounts to Rs. 1,04,795: to this has to be added the value of the 4 small tanks proposed to be thrown out of cultivation, *vide* para 21, the total value may therefore be taken as 1,20,000. This estimate was made up at the request of the Dewan, the Mysore Government will not of course have to pay for their own tanks.

59. *Distribution.*—This is taken at Rs. 3½ per head and is what has been allowed in other water-supply projects for Civil and Military Station, the total cost allowing 250,000 people will be Rs. 8,75,000. No attempt has been made to work out the detail of the cost of distribution. Rs. 3½ per head is what has been allowed in other schemes for the supply of Civil and Military Station. but as the City is more compact, it is probable the average cost will be less.

60. *Establishment, Tools and Plant.*—It will be necessary to allow 24½ per cent on all items representing work, in fact on the cost of project less value of tanks, compensation, cost of piping, stand-pipe, rising main and delivery pipe; this amounts to Rs. 1,80,000. This item has not been allowed in any of the projects hitherto prepared except Major Grant's Malligal Project. It seems absurd to suppose that such a large sum will be required for a work that should not last more than 3 years and for which no special machinery or appliances will be required.

61. *Contingencies.*—Five per cent on the total estimate is allowed on this account.

62. *Unforeseen Expenses.*—For this a sum of Rs. 58,200 has been entered on this account. Not allowed in other projects but advisable.

63. *Abstract of Estimate.*—

		Rs.
1	Head Works	1,48,000
2	Delivery Channel	150,000
3.	Settling Tanks	44,300
4.	Pumps and Engines	2,00,000
5.	Rising Main	1,70,000
6.	Engine House	20,000
7.	Quarters for Establishment	16,000
8.	Stand Pipe	3,500
9.	Delivery Main	7,23,000
10.	Filtering Reservoir	34,000
11.	Service Reservoir	1,22,000
12.	Compensation	1,00,000
13.	Value of Tanks	1,20,000
14.	Distribution	8,75,000
		27,25,800
	Contingencies at 5 per cent	1,36,000
	Establishment, Tools and Plant at 24½ per cent on all items of cost	1,80,000
	Add for unforeseen expenses	58,200
	Total	31,00,000
		or 31 Lakhs.

64. *General Remarks on Estimate.*—The estimate is, it is believed, a very liberal one and there is no chance of it being exceeded, on the contrary a saving can probably be effected on items 2, 5, 9 and 14.

65. *Cost per head.*—The cost 31 lakhs seems high and this represents a charge of Rs. 12-4 per head of the population to be supplied and about Re. 1 per gallon per diem, but this compares favorably with many other water-supply projects, *vide* Appendix 7 of Colonel Mullin's report on the Bangalore Water-supply, from which it can be seen that in the case of the Inchalkaranj water works the cost per head was 13·6 per head. In the Jalgaon water works Rs. 13·9 per head, in the Lahore water works 11·5 per head, and in the Secunderabad water works Rs. 4 4 per gallon. It would be interesting if the cost of other water-supply scheme such as Bombay, Poona, Kirki, &c could be ascertained for the sake of comparison.

COST OF SCHEME WITH REDUCED SUPPLY RECOMMENDED.

66. If the schemes for supplying 200,000 people with 10 gallons a day be adopted, there will be a considerable reduction in the cost of the estimate as follows.

67. *Head Works.*—The cost of head works will then be approximately Rs. 1,40,000 owing to reduction in size of water tower.

68. *Delivery Channel.*—The delivery channel will cost about Rs. 30,000 less or Rs. 1,20,000 as it will only have to discharge 3·7 c. ft. instead of 5·7 c. ft. a second.

69. *Settling Tanks.*—The settling tanks will not cost more than Rs. 30,000 as they need only contain 2,000,000 gallons instead of 3,125,000 gallons, each.

70. *Pumps and Engines.*—The pumps will have to lift 3,240·73 gallons per minute instead of 5,063 6 and they will therefore be cheaper and the price may be taken approximately at Rs. 1,80,000.

71. *Stand-Pipe.*—The stand-pipe will cost say Rs. 3,000 against Rs. 3,500. In this case the stand-pipe will have to be 60′ high and the lift will be 375′.

72. *Delivery Main.*—With the reduced supply the delivery main need only be 20′ internal diameter, for a length of 18,282′ the head may be taken as 360′, the thickness of metal will therefore be 1″, for a length of 18,678′ the head may be taken as 140′ and the thickness of metal will be $\frac{7}{10}$″

The weight per foot of 20″ pipe 1″ thick is 204 lbs. per foot, therefore the weight of 18,282′ will be 1,665 tons and at Rs. 150 per ton cost will be Rs. 2,49,750. The weight per foot of a 20″ pipe $\frac{7}{10}$″ thick is 142 lbs. per foot, therefore the weight of 18,678′ will be 1,184 tons and the cost at Rs. 150 per ton will be Rs. 1,77,600. The total cost of the piping will thus be Rs. 4,27 350, to this must be added Rs. 36,960 for laying and Rs. 6,500 for valves, making the total cost of the delivery main Rs. 4,70,810 against Rs 7,20,000.

73. *Rising Main.*—The rising main will be 20′ diameter 1″ thick and will therefore weigh 204 lbs per foot, the length being 8,580′; the total weight will be 781·4 tons and at Rs. 150 a ton, cost of pipes will be Rs. 1,17,210, add for laying, building masonry pillars, &c. Rs 9,000, total cost Rs. 1,26,210 say 1,30,000 against Rs 1,76 000.

74. *Filtering Reservoir.*—The filtering reservoir may be smaller and the cost taken at Rs. 25,000.

75. *Service Reservoir.*—The same amount, *viz.*, Rs. 1,22,000 will be left for Service Reservoir as it is desirable that it should hold more than a 3 days' supply

76. *Distribution.*—Distribution at Rs 3½ per head will be Rs 7,60,000.

77. *Other items.*—The other item will remain as before, the total cost of the reduced scheme will therefore be as follows:—

78. *Abstract of cost of reduced scheme.*—

	Rs.
1. Head Works	1,40,000
2. Delivery Channel	1,20,000
3. Settling Tank	30,000
4. Pumps and Engines	1,80,000
5. Rising Main	1,30,000
6. Engine House	20,000
7. Quarters for Establishment	16,000
8 Stand-pipe	3,000
9. Delivery Main	4,70,000
10 Filtering Reservoir	25,000
11 Service Reservoir	1,22,000
12 Compensation	1,00,000
13 Value of Tanks	1,20,000
14 Distribution	7,60,000
	22,36,000
Contingencies at 5 per cent	1,11,800
Establishment and Tools and Plant	1,30,000
	24,77,800
Unforeseen Expenses, Say	47,200
Total	25,25,000
or	25¼ Lakhs

79. *Results.*—Thus it will be seen that the present population of Bangalore being 180,000, a supply of water at the rate of 10 gallons per head per diem for 200,000 people to last through 3 years of a minimum yearly rain-fall of 17″ can be secured at a cost of 25¼ lakhs, and this being the case, it does not seem desirable to expend 31 lakhs on the larger scheme.

80. *Proportion of Cost.*—Taking 31 lakhs, the proportion to be paid by the British and Mysore Government would be respectively 17·33 lakhs and 13·77 lakhs and taking 25¼ lakhs, the proportion would be 14·03 and 11·22 lakhs.

81. *Comparision of cost with other projects.*—It will be interesting to compare the cost of this project with some others that have been prepared and the following shows the result:—

Mr. Lawrence's Malligal.

Scheme cost Rs. 9,79,754.
Supply 668·75 thousand gallons.
Cost per 10 gallons Rs. 14·6.

Mr. De Winton's Malligal.

Scheme cost Rs. 11,90,000.
Supply 668·75 thousand gallons.
Cost per 10 gallons Rs. 17·7.

Major Grant's Malligal.

Scheme cost Rs. 19,05,050.
Supply 668·75 thousand gallons.
Cost per 10 gallons Rs. 28.

Present scheme.

Cost Rs. 31,00,000.
Supply 3,125,000 gallons.
Cost per 10 gallons Rs. 9·9.

Reduced present scheme.

Cost Rs. 25,25,000.
Supply 2,000,000 gallons.
Cost per 10 gallons Rs. 12·62.

So that it will be seen that as regards cost of supply per gallon the present or Hessarghatta project is the cheapest,

82. *Remarks on other water supply projects of Bangalore.*—Numerous water-supply projects have been prepared for Bangalore and it is believed they have all been finally rejected except the Hebbal and the Malligal.

83. *Hebbal Scheme.*—As it is now proposed to have a joint scheme for the City and Civil and Military Station, Hebbal Tank as a source of supply may be put out of the question as the free catchment area is only 4½ square miles, and the total 12½ square miles, and the supply would be quite insufficient even supposing all the tanks in the series were brought up.

84. *Madigal or Malligal Scheme.*—Major Grant has lately investigated the Malligal scheme and estimates the cost at Rs. 19,05,050.

The objections to this scheme are—

1st the catchment area though a very excellent one both as regards purity and run-off, is only 10 square miles and this would be quite insufficient to give a yearly supply of 182 500 or even the reduced supply of 116·8 million c. ft. during bad years.

2nd The supply could perhaps be increased by making long and expensive contour channels into other valleys, but even if this were done, the storage would be a difficult matter as several dams would be required and it is doubtful if sites for them can be found, and moreover, these contour channels would drain very highly cultivated land and thus do away with any advantage; the Madigal scheme has over the Hessarghatta as regards purity of catchment.

All things considered, it may safely be asserted that for a joint water-supply scheme the Hessarghatta possesses advantages superior to all others.

85. *Hebbal and Madigal combined.*—It has been suggested that the Hebbal Tank might be used to supply the Civil and Military Station and Madigal valley the City; but even supposing the supply to be sufficient, the united cost would be more than that of the Hessarghatta as follows —

	Rs.
Cost of Hebbal Scheme Vide General Fisher's report and Col. Bowen's note thereon	3,00,000
Value of tanks	1,50,000
Compensation	2,00,000
Distribution	5,25,000
Establishment and Tools and Plant	25,000
Contingencies	50,000
Total ..	12,50,000

This estimate is only approximate and is probably below the mark Cost of Madigal scheme as estimated by Major Grant, R. E., Rs. 19,05,050.

Total cost of the two schemes, Rs. 31,61,000 against Rs. 31 or 25¼ lakhs and it must be remembered that the Hessarghatta scheme supplies 12½ and 10 gallons per head for natives, while the other schemes only allow 6¼ It must also be remembered that the working expenses of two schemes will be double or more than double that of one.

WORKING EXPENSES

86. It will now be necessary to consider the working expenses first taking the larger estimate of 31 lakhs

87. *Interest on Capital.*—Interest at 4 per cent=1,24,000

88. *Loss of Revenue on land taken up.*—The yearly loss of revenue under the Bata, Kakol and Hessarghatta Tank will be Rs 3,145 it is regretted that accurate information cannot be given with regard to the other tanks as it has not been received from the revenue authorities, but as they are all small it is thought that the total loss cannot exceed Rs 5 000

89. *Establishment.*—1 Overseer to superintend the complete system on Rs 60=720.

1 Reservoir Superintendent and 3 Peons at Hessarghatta to regulate the supply and watch the tanks:—

	Rs.
Superintendent, Rs 20 per month	240
3 Peons, Rs. 18	216
2 Watchmen on Banawar Hill at Rs 6	144
2 Engine Drivers at Rs 20	480
2 Stokers at Rs 7	168
2 Coolies at Rs 6	144
Total Establishment.....2,112	

90. *Depreciation.*—Depreciation of machinery, 7 per cent on 2 lakhs (2,00,000) . . ... Rs. 14,000

Depreciation of pipes, valves, &c., including distribution pipes at 4 per cent on (14,50,000) . 58,000

Fuel and small stores 20,000

91. *Repairs.*—Repairs at 1 per cent. 31,000

92. *Total.*—The total working expenses will therefore be Rs. 2,54,112, say Rs. 2,55,000 or about Rs. 1 per head of population taken as 250,000.

93. *Working Expenses on Reduced Scheme.*—Taking the smaller estimate of 25¼ lakhs, the working expenses work out as Rs. 1,86,000 or about annas 14·8 per head for a population of 200,000.

94. *General Remarks on cost of working Expenses.*—This does not appear to be by any means an exorbitant taxation to impose for a good water-supply and what it really amounts to, is that each person will receive 2,190 chatties holding 2 gallons each of pure water a year at a cost of $\frac{1}{730}$ of an anna per chatti or that is, will receive delivered almost at his door 130 chatties or about a 26 days' supply for one anna.

95. *Interest on Capital.*—In case an unfavorible comparison may be made as regards the working expenses of this project as compared with those of others, it may be mentioned that it is believed that in no other case has the interest on capital been added and this is a large item.

96. *Concluding Remarks.*—In conclusion, it is requested that it may be borne in mind that this is only a preliminary report submitted with the object of enabling it to be decided at an early date whether the project should be investigated in detail or not.

97. *Accuracy of Estimates.*—Mr Scaldwell has worked out the cost of the different items with great care and in considerable detail, but the figures cannot be accepted as absolutely correct, though it is believed that the total will be within a few thousand rupees of the correct amount, and that any errors, there are, will be on the right side.

BANGALORE,
26th January 1893.

D. McNEIL CAMPBELL, LIEUT.-COL., *R. E.*,
Secy to the Govt. of Mysore, P.W.D.

REPORT ON PROJECT FOR SUPPLY OF WATER FOR BANGALORE FROM THE HESSARGHATTA TANK, REGISTERED No. 73. NELA-MANGALA TALUK, BY THE EXECUTIVE ENGINEER, BANGALORE DIVISION

The Dewan of Mysore in his letter of the 31st October 1892, calling for the submission of a report on the proposed project, forwarded a memo giving the scope of the same, from which the undermentioned particulars have been taken :—

2. According to the Census of 1891, the population of the Civil and Military Station is 100,081 and that of the City, 80,285. Total 180,366.

3. When the Census was taken in 1881, the total population was 155,857—the increase in ten years being 24,509, which is at the rate of 157·2 per thousand.

4. With view of meeting the increasing requirements of the Station, provision should be made for the supply of water for a population of 250 000, at the rate of 2 c. ft. per head per day, and reservoir should be of a capacity to store a supply for three years.

5. The source of supply to be the Hessarghatta, Byata, Kakol, Arsinkunte, and Chik Devanpûr Tanks, situated in the Arkavati Valley, and to insure ample storage, the Dewan proposed that the weir of Hessarghatta Tank should be raised 15 feet, and weirs of Byata and Kakol Tanks 6 feet.

6. *Locality of Supply.*—The Hessarghatta Tank is situated in Latitude 13°-9′ and Longitude 77°- 31½′, *vide* Topographical Survey Sheet No. 42. It is the terminal tank of the Hessarghatta series, which consists of 184 tanks and three "kattes," divided into seven sub-series, particulars of which will be found under the heading "Catchment Area."

7. Byata Tank lies 2½ miles to the north of the village of Hessarghatta and Kokal Tank is situated immediately above the Hessarghatta Tank at a distance of 3½ miles higher up the Arkavati river, across which like the Hessarghatta Tank, it is constructed.

8. Arsinkunte and Chik Devanpur Tanks are very small ones the former being on the east, and the latter on the west of the valley.

9. In addition to the five tanks mentioned by the Dewan, there are three small tanks, Dyavara Kunte, Jumbalpete, and Somanahalli, the former situated on the east of the valley, and latter two on the west, all of which must necessarily be thrown out of cultivation, as they drain directly into the Hessarghatta Tank.

10. *Present condition of tanks forming storage reservoir.*—Hessarghatta Tank, Registered No 73, Serial No. 187 Nelamangala Taluk—Constructive details are as follows :—

Waste weir on left at R. L. 50 00 or M. S. L. 2804·17 and 990 feet long.
Bund R. L. 60 00 and top width from 10 to 57′.
Revetment..R. L. 56 00.
Area of tank at R. L. 50 00=16 28,795 square yards.
Capacity at R. L. 50 00=70 684 million c. ft.
Right sluice. R. L. 28·95 or M. S. L. 2793·12.
Left sluice R. L. 43 55 or M. S. L. 2797·72.

*Note.—Crest bund on right flank which is only 220 yards in length, is the only portion of bund with top width less than 20 feet.

Bund and revetment in good order.
Right sluice in good order.
Left sluice somewhat leaky.
Weir—some leaks in left flank of body wall and left wing, and apron requires extensive repair.

11. Tank is stated to have been nearly dry last year, but crops were cultivated below it as usual, at time of inspection (8th December 1892) the level of water was ·65 feet below crest of weir and during the year there was 2 feet of water passing over the weir, which discharged at depths varying from 6 inches to 2 feet for sixteen days.

12. To carry out the Dewan's proposal to raise the water level 15 feet, the construction of a new weir on the high ground on the left of the tank will be necessary; and details of work proposed to be done are given in statement relating to the cost of the project.

Byata Tank.—Registered No. 206, Serial No. 182, Dodballapur Taluk.

Constructive details are as follows:—

Waste weir on right at R. L. 52·00 and 102 feet in length M. S. L. 2,835.

Waste weir on left at R. L. 52·00 and 123 feet in length.

Bund ...R. L. 61 00 and top width 12 feet.

Revetment R. L. 57·00.

Area of tank at R. L. 52·00=762,758 square yards.

Capacity at R. L. 52 00=22·986 million c. ft.

Sluice on left, R. L. 43·88.

Sluice on right, R. L 47·24.

14. Right weir consists of a rough stone apron, laid at a slope of 1 in 12—a pit 6 feet in depth has been scoured out below the apron, at a distance of 31 feet from it, but as there is an outcrop of rock immediately below the toe of the apron, no damage is likely to occur to the weir.

Left weir in good order, and consists of a masonry body wall, with returns and a rough stone apron 138 feet in length, laid at a slope of 1 in 10—a pit 10 feet in depth has been scoured out in kodi nala a short distance below the apron, but as there is a reef of rock running between the apron and pit, the erosion of bed of nala does not endanger the safety of the weir.

Bund is in good order but requires turfing.

Revetment in fair order.

Sluice in good order

15. Tank was quite dry last year—on date of inspection (9th December 1892) water was 1 ft below the crest of weir, and in June last, there was a depth of 1½ feet spillage on the weir, from the run-off from the tank's own catchment—when water is passing over the weirs of Amane Madure Tank, situated immediately above, the depth of discharge on the weir of Byata Tank is 3 feet.

16. The raising of the water level 6 feet would necessitate the execution of the following work:—

Construction of a new weir on the high ground on the right flank, for which some heavy earthwork, in the way of draught channel, would be needed; construction of a body wall in front of the left weir with slabbed overfall, which would be very costly owing to the bed of tank, where new body wall would have to be constructed, being 5 feet below crest of present weir.

Raising bund to R. L. 64·00 and revetment to R. L. 62·00.

17. *Kakol Tank.*—Registered No. 200, Serial No. 134, Dodballapur Taluk.

Constructive details are given below:—

Waste weir on left at R. L. 53·00 and 212 feet in length M. S. L. 2,834.
Bund R. L. 62·00 and 9 feet in width at top.
Revetment R. L. 62·00.
Sluice on right R. L. 43·41.
Sluice on left R. L. 43·88.
Area of tank at 53·00 (present weir level) 1,551,489 square yards.
Capacity of tank at 53·00=78 845 million c. ft.

18. Bund, revetment, and both sluices in good order. Weir on left consists of a masonry body wall and rough stone apron 92 feet in length (laid at a slope of 1 in 6) with masonry toe wall and slab binding walls—the left sluice passes through the apron, and tunnel in connection with it forms a masonry binding wall for apron—the weir is in good order, but the ground below the toe wall has been scoured out 4 feet in depth for a distance of 150 feet, and extension of apron throughout this length is necessary, and will be put in hand shortly

19. Tank was dry last year at time of inspection (10th December 1892) water was within 6″ of crest of weir, and on the 30th of September, 3 feet of water was passing over it—the discharge over the weir during current year varied from ½ inch to 3 feet in depth for 33 days.

20. The undermentioned work will be necessary in connection with raising the water level 6 feet.

Construction of body wall in front of the weir with slabbed overfall

Raising bund to R. L. 67·00 and revetment to the same height.

The construction of new body wall will be very costly, as the bed of tank on right flank, where it must be constructed, is 5 ft. below the crest of present weir; but there is not, I think, any alternative, as even if a new weir was constructed on the high ground to the left of the present kodi, the apron would have to be carried down to the level of toe of present apron, and construction of such a weir would prove much more expensive than that of a body wall in front of present weir.

21. In connection with the raising of weir level of this tank, I would beg to bring to notice that from the plans showing the work executed in connection with the restoration of the tank in 1877-78, it would appear that the bund was very badly breached in places, and it is to be feared that raising the weir 6 ft. in addition to the 3 ft. which it has already been raised, will possibly prove disastrous.

22. *Somanhalli Tank.*—Registered No. 211, Serial No. 136, Dodballapur Taluk.

Constructive Details.

Weir on right at R. L. 50·00 and 50 ft. in length.
Bund at R. L. 54·50 with top width of 4½ ft.
Revetment ...R. L 54·00
Sluice ...R. L 43·50
Area of tank at .R. L 50·00=91,843 square yards.
Capacity of tank at . R. L 50·00=3·113 million c. ft
Bund and revetment in good order.
Sluice leaky.

Weir consists of only a rough stone apron 12 ft. in width, which should be extended 20 ft. as kodi nala has cut back to a depth of 3½ ft., within 10 ft. of apron.

Tank quite dry at time of inspection, the water stored during the year having only sufficed for cultivation.

23. *Chik Devanpur Tank.*—Registered No. 210, Serial No. 183, Dodballapur Taluk.

Constructive Details.

Weir on right at R. L. 50·00 and 36 ft. in length.
Bund at R. L. 54·50 with top width of 4½ ft.
Revetment at R. L. 54·00.
Sluice . . R. L. 46·31.
Area of tank at R. L. 50·00=81,621 square yards.
Capacity at R. L. 50·00=2·090 million c. ft.
Bund in good order.
Revetment bulged somewhat in places, but in fair order.
Sluice leaky and requires repair.

Weir—consists of a few rough stones laid as an apron—a masonry body wall 36 feet in length, with returns, and rough stone apron 12 feet in width wanted.

Tank dry at time of inspection, all the water stored having been used for cultivating.

24. *Jumbinkere Tank.*—Registered No. 71, Serial No. 186, Nelamangala Taluk.

Constructive Details.

Weir on left at R. L. 50·00 and 101 feet in length.
Bund at R. L. 54·50 and top width 4½ feet.
Revetment at R. L. 53·00.
Sluice at R. L. 42·58
Area of tank at R. L. 50·00=186,088 square yards.
Capacity at R. L. 50·00=6·263 million c. ft.
Bund, revetment and sluice in good order.

Weir—consists of masonry body and toe walls with rough stone apron 24 ft. in width—ground below the weir scoured out to a depth of 3½ ft., by a water course on left flank that enters the kodi nala just below the apron—scour will not damage weir, as there is rock and laterite immediately below the toe wall.

Tank dry at time of inspection, as water stored proved only sufficient for cultivation. From marks on gauge stone it would appear that there is frequently a discharge of 3 feet in depth on the weir.

25. *Arasinkunte Tank.*—Registered No. 204, Serial No. 2, Dodballapur Taluk.

Constructive Details.

Weir on left at R. L. 50·00 and 36 feet in length.
Bund at R. L. 54·50 and 4½ feet in width at top.
Revetment—none, as front slope has been made 3 to 1 and turfed.
Sluice at R. L. 46·33.
Area of tank at R. L. 50·00=69,696 square yards.
Capacity at R. L. 50·00=1·082 million c. ft.

Bund is somewhat eroded at weir level, owing to neglect of renewal of turfing.
Sluice in good order.

Weir consists of rough stone apron and masonry toe wall. Kodi channel has cut back and caused the collapse of the toe wall and displacement of the whole of the apron which is 15 ft. in width. A masonry body wall 36 ft. in length, with returns, and apron 30 ft. in width, carried down to bed of nala, is needed.

Tank dry at time of inspection, the water stored having proved hardly sufficient for cultivation.

26. *Dyavarakunte Tank.*—Registered No. 205, Serial No. 1, Dodballapur Taluk.

Constructive Details.

Weir at R. L, 50·00 and 25 ft. in length.

Bund at R. L. 54·50 with top width of 4½ ft

Revetment—none, the front slope having been made 3 to 1, and turfed.

Sluice at R. L. 46·00.

Area of tank at R. L. 50·00=81,544 square yards.

Capacity at 50·00=1·749 million c. ft.

Bund—front slope eroded at weir level owing to neglect of renewal of turfing.

Sluice in good order.

Weir is a natural one, and no work is needed to it.

Tank dry, the water stored having proved only sufficient for the cultivation, notwithstanding half of the cultivable area below the tank has been taken up for casuarina plantations.

27. The annexed statement gives the approximate value of the eight tanks, comprising the project as they now stand:—

Statement of present value of eight Tanks comprising the Hessarghatta Project.

Serial No.	R. No.	Name of Tank.	Storage.				Distribution.		Silt Dams.	Total.	Expenditure subsequent to 1876.	Grand Total.	Remarks.
			Earth work to bund.	Revetment.	Tank waste weir.	Total.	Tank-sluice.	Total.					
1	205	Dyavarakunte ...	1,009	391	...	1,400	..	..	...	1,400	624	2,024	
2	204	Arsinakunte ...	898	281	94	1,233	160	160	..	1,393	563	1,956	
134	200	Kakol Tank ...	11,729	4,471	2,989	19,189	727	727	61	19,977	18,082	38,059	
136	211	Sonnainhalli Attikunte ..	1,057	831	133	2,021	241	244	..	2,278	346	2,624	
182	206	Byata Tank ...	6,687	2,267	1,708	10,682	199	199	..	10,881	1 952	12,833	
183	210	Chik Devanpura Tank ..	1,107	803	...	1,910	202	202	...	2,112	237	2,349	
186	71	Jumbinkere ...	1,628	759	618	3,005	302	302	...	3 307	941	4 248	
187	73	Hessarghatta Tank ...	11,768	10,140	1,011	26,222	1,239	1,239	...	27,161	13,241	10,702	
								Total Rs.		68,809		1,04,79	

28. *Storage Reservoir Capacity*—From the statement given below, it will be seen that the present capacity of the eight tanks included in the project is 206 736 million cubic feet, and that after raising the weir of Hessarghatta Tank 15 ft and weirs of Byata and Kakol Tanks 6 ft. the capacity will be increased to 1047·170 million c. ft. The Sonnainath, Chik Devanpur Jumbinkere, Arsinakunte and Dyavarakunte are very shallow tanks and their capacity, with the exception of that of Jumbinkere, should the tank be omitted when considering the question of storage, as the water stored in them would be lost by evaporation and percolation by the close of the year.

Name of Tank.	Present weir level.	Area of water-spred in acres.	Capacity in m.c.ft.	Proposed height of weir.	Approximate area of water-spread in acres.	Approximate capacity in m. c. ft.	Remarks.
Hessarghatta ...	50·00	374	89·556	65·00	* 1702	*767·337	Water-spread and capacity of all the tanks at R. L. 50·00 and 53·00 have been taken from the serial plans and water-spread and capacity at R. Ls. higher than 53·00 have been computed from that data. * Contour survey at R. L. 65·00 since taken and area of water-spread and capacity found to be 1,702 acres and 767·337 m. c. ft.
Byata ...	52·00	157·59	22·986	58·00	302	85·639	
Kakol ...	53·00	320 55	79·897	59·00	14·7	179·895	
Sonnanhalli ...	50·00	18·97	3·113	50·00	1897	3·113	
Chik Devanpur ...	50·00	16·86	2·090	50·00	16·86	2·090	
Jumbakere ..	50 00	38·44	6·263	50·00	38·41	6·265	
Arsinakunte ..	50 00	14·40	1·082	50·00	14·40	1·082	
Dyavarakunte ..	50 00	16·84	1·749	50·00	16·84	1·749	
Total.. ...		957·65	206·736	...	2,556·51	1,047·170	
Total of Hessarghatta, Byata and Kakol tanks with weirs of former raised 15 ft. and those of two latter tanks 6 ft. ...					2,451	1,032·871	
Total of Hessarghatta with weir raised 15 ft. and of Byata and Kakol with weirs at present level					2,180	870·220	

29. *Quantity of water to be stored.*—To store a supply of water for 3 years, at the rate of 500,000 c. ft. per day, a reservoir of capacity of 547·500 m. c. ft. is required, and as the Hessarghatta Tank alone, with weir raised 15 ft., will store 219·837 m. c. ft. and with Byata and Kakol Tanks at present weir level 322·720 m. c. ft. in excess of this quantity, I would submit that storage reservoir should be restricted to Hossarghatta Tank with weir raised 15 ft., and Byata and Kakol Tanks at present weir level.

30. *Grounds for recommending restriction of storage reservoir.*—1st. Unnecessary, as during ordinary years there will be a constant supply from the tail water of the numerous tanks above, which will replenish quantity used and lost by evaporation for some time, and probably keep the Tanks full up to end of January.

2*nd*. The raising of the weirs of Byata and Kakol Tanks 6 ft., would cause the submersion of about 88 acres of wet, and 183 acres of dry land, which at Rs. 75 * and Rs. 36 * per acre, respectively, would amount to Rs. 13,005 which sum, together with the cost of work in connection with the raising of the weir (approximately Rs. 50,000) would be more advantageously expended on payment of compensation for land thrown out of cultivation under other tanks, (which will be hereafter mentioned) with view of increasing the catchment area.

3*rd*. The raising of weir of Kakol Tank 6 ft. in height is considered inadvisable for reasons given in para 21 of this report.

31. *Percolation and Evaporation.*—The present bund of Hessarghatta Tank is strong and sound, and there is very little percolation. The bed of tank consists of clay, and ground on both flanks of red loamy soil, with decomposed gneiss underlying it, at a depth of 8 feet below surface ; consequently, if excavation of pits within the margin of future waterspread is prohibited, and a good puddle wall carried down 3 feet below silt level at toe of present bund, also the usual precautions are taken with the extension of bund on both flanks, it is believed the loss attributable to percolation will be very small, certainly not more than 15 per cent of quantity stored.

* From enquiries made with regard to land recently sold, these rates are believed to be fair average ones.

32. Allowing as usual 6 feet loss per annum on account of evaporation, the quantity of water available in the reservoir towards the close of the first year, supposing all the tanks comprised in the project to have been full to start with, and no run-off to have been received during the South-West Monsoon, would be 245·655 m. c. ft. as per details given in annexed statement :—

Contour.	Area in acres at contour.	Capacity in M. C. ft. at contour.	Capacity in units at contour.	Remarks
50·00 ..	374	89·817	344	Area and capacity at the several contours are based on area and capacity at 50 00 and 53·00 as actually surveyed
53·00 ..	508	148 303	568	
56·00 ...	905	256 658	983	
59·00 ...	1,171	392 428	1,503	
62·00 ...	1,436	562·402	2,154	
65·00 ...	1,702	767·337	2,939	

Percolation at 15 per cent of capacity of reservoir ..	115·098 m. c. ft.
Annual consumption at 500,000 c. ft. per day	182·500
Evaporation allowing 6 feet in depth per annum .	340·209
Total	637·807
Total Capacity of Reservoir	767·337
Balance	129 530
† Add quantity stored in the other seven tanks ..	116·125

Water available in reservoir at end of first year under conditions stated in para 32, 245·655 m. c. ft.

Evaporation has been calculated at 6 feet in depth on the mean area between 56·00 and 65 00.

No deduction on account of percolation and evaporation has been made from storage of other tanks, as the percolation would find its way into the Hessarghatta Tank, and the evaporation would be very little, as water would be run out of the tanks immediately the level of water in the Hessarghatta Tank fell below the weir.

33. In the above calculations no allowance has been made for the tail water from cultivation and percolation from tanks situated above the Hessarghatta Tank, (which is undoubtedly a large quantity, as notwithstanding 65 m. c. ft. of water (over two-thirds of capacity of tank) is used annually for cultivation, yet the tank is generally half full at the end of the season during years of ordinary rain-fall.

34. *Catchment Area—Extent.*—The total catchment area of the Hessarghatta Tank, and the 183 tanks situated above it, is 211·78 square miles ; (*vide* Statement B) of which the catchment area 22·78 square miles (see Statement A) of Hessarghatta, Byata, Kakol and the five minor tanks comprised in the project is free.

Statement A, showing catchment area, capacity, area of cultivable land, assessment, &c., of eight tanks comprising project.

Serial No.	Name of Tank	Catchment area in acres	Present capacity in units.	Cultivable area and assessment as per Revenue Survey statement						Area under cultivation and revenue realized during 1891-92.						Average revenue realized during past 10 years.	Remarks
				Wet land.	Assessment.	Garden.	Assessment.	Total.	Assessment.	Wet land	Revenue	Garden.	Revenue	Total	Revenue.		
187	Hessarghatta	4,405	344	211 33	1,233—12	110 19	628-4	322·12	1,862	202·27	1,216	110 19	628—4	313·C	1,844-4	‡ 1,095 11 8	† Actual amount realized was only Rs. 1,344—9—0. *Not $\frac{1}{4}$th cultivated. ‡ Little over $\frac{1}{3}$rd cultivated.
182	Bjata ..	4,954	88	227 22	1,486	5·95	48	233·17	1,534	75 18	492–12	10 17	77—8	85 35	574	612 4 10	
134	Kakol ..	2,553	305	351 22	2,244—8	12 9	53-8	363 3	2,298	123·33	791—8	11·20	50—12	†135·3	842 4	963 4 10	
136	Sonnanhalli	401	12	50 13	251	1 36	15	52 9	266	44·9	220	1 36	15	46·5	235	152 0 0	
183	Chikdevanpur	463	8	32 27	173	2 13	19	35	192	27 37	142	2 13	19	30 10	162	92 0 0	
186	Jumbinkere .	930	24	...	...	...	..	...	...	...	...		..		..	...	
1	Devankunte ..	318	6 7	25 6	112	6 24	12	31·50	124	25·6	122	6 24	12	31·30	124	60 0 0	
2	Arsinkunte ..	498	4	19 29	82	1 29	3	21 18	85	19 29	82	1 29	3	21·18	84	47 0 0	
		14,582 or 22 78 square miles	791 7 or 206·736 m. c ft.														

From this statement it appears that only $\frac{10}{16}$ of the cultivable land, below the 8 tanks is occupied, the calculation of compensation payable for land thrown out of cultivation by submersion, &c, has been restricted to the actual area on which assessment is now paid. The remainder of the land is valuable as pasturage and would be gladly taken up by the raiyats at a reduced rate for cultivation of other than wet crops

Statement B, showing capacity and catchment area of all tanks in the Hessarghatta Series.

Name of sub-series.	Number of tanks in sub-series.	Serial Numbers of tanks in sub-series.	Capacity in units	Catchment area of tanks in acres.	Cultivable area below tanks.	Situation of sub-series with reference to the Hessarghatta works.	Remarks.
Byata	55	1 to 2 & 135 to 187	2,374 1	46,229	4,535	North-West.	In this sub-series, the run-off from the catchment of 38 52 square miles would be 269·64 m. c. ft. (1,032 units) during a year of minimum rain-fall; so that even during a bad year, more than half the catchment may be considered free
Kolatur	39	3 to 41	471	24,651	1,326	North-East.	
Naganhere	35	47 to 81	1,045 8	23,494	2,749	Do	
Jumbinkere	16	84 to 99	605·2	13,398	1,283	Do	
Ar amallge	25	100 to 124	1,071 4	17,775	1,975	North-West.	
K.a.	10	125 to 134	228·3	6,490	530	North-East.	
Minor tanks	4	42, 45, 46, 83	68·3	3,497	277	...	
Total	184	...	5,867 1	135,534	12,675		
Deduct catchment and capacity, &c, of eight tanks included in project (see statement)			791·7	14,582	1,115		
Balance.....			5,075·4	120,952 or 189 sqr miles	11,560		

Allowing 7 m c ft per sq. mile as minimum run-off, the supply from 189 sq miles would be 1,296 m. c. ft. or 4,963 units, which would hardly fill the tanks, the capacity of which is 5,075 units.

With an average run-off of 11 m c ft per sq mile, the total supply would be 2,179 m. c ft or 8,345 units, and surplus would be 3,270 units or 853·785 m. c ft.

With a maximum run-off of 17 m c ft. per sq mile, the surplus would be 7,130 units or 1,861·618 m. c ft., which is upwards of three times the capacity of the whole of the eight tanks comprising the project

35. In addition to the above free drainage area, the catchment area 8·85 sqr. miles of the 12 tanks situated in the vicinity of the Hessarghatta Tank (noted in Statement C) is really free to the extent of the $\frac{2}{3}$rds of the run-off during average years, and $\frac{1}{2}$ during years of minimum rain-fall, the tanks situated within that area being so small compared with the catchment that not more than $\frac{1}{3}$rd of the run-off during ordinary years can be impounded.

Statement C of tanks draining into Kakol and Byata tanks, the catchment area of which is practically free to the extent of $\frac{2}{3}$rds of the run-off during years of average rain-fall and $\frac{1}{2}$ during years of minimum rain-fall.

Serial No.	Register No.	Name of Tank.	Taluk.	Catchment area in acres.	Capacity of Tank in M. C. ft.	Cultivable Area.	Remarks.
			North of Byata Tank.				
137	209	Sheresandra	Dodballapur	899	8,113,041	79	Capacity of tank only sufficient for cultivation of 32 acres as a Vaisakha crop
181	310	Kodihalli	Do	407	5,334,763	45	Do 20 do
180	317	Kallodakere	Do	300	2,999,160	30	Do 12 do
179	318	Kalloda Ané	Do	300	1,290,249	11	Do 5 do
...	46	Iyankatte	Do	381	...	17	
178	47	Matta Gaudanakere ...	Do	281	2,633,233	22	Do 10 do
			North of Jumbukere Tank.				
184	319	Mestri Palya ..	Dodballapur	253	288,468	3	
185	70	Elchalahalli	Nelamangala ...	380	769,419	23	Do 3 do
			North of Sornambli.				
135	213	Karlapura Palya ...	Dodballapur	652	3,047,031	27	Do 12 do
			North of Kakol Tank				
131	214	Nellikere .. .	Dodballapur	402	1,613,709	8·8	Do 6 do
132	234	Chellahalli Palya ...	Do	516	3,632,804	62·8	Do 14 do
133	200	Aiyan Ané Harur ...	Do	896	3,979,393	77·2	Do 15 do
			Total	5,667 or 8·85 sq miles.	33,751,375 or 129·26 units.	405·8 acres.	

36. With reference to run-off from other tanks, I would here mention that the whole of the Kolatur sub-series is similar in this respect, the catchment area being 38·52 sq. miles, from which a run-off of 269·64 m. c. ft. (1,032 units) could be anticipated during a year of scanty rain-fall, while the capacity of the 39 tanks comprised in the sub-series is only 471 units—the tanks however are very much scattered and at a long distance from Hessarghatta; consequently it has been considered advisable to deal with the surplus run-off from Kolatur sub series, in the same way as with the other sub-series.

37. A further free catchment area of 3·21 sq miles might be obtained by throwing out of cultivation the wet land below the four tanks mentioned in Statement D; and if project is carried out, I would strongly recommend this being done, as the free catchment area mentioned in paras 34 and 35 is insufficient during years of minimum rain fall when no surplus is available from the numerous tanks above.

Statement D. Tanks which might be taken up to increase the catchment area.

Serial No.	Register No.	Taluk.	Name of tank.	Catchment area in acres.	Capacity of tank in C. ft.	Cultivable area below tank.	Remarks.
			Tanks west of Kakol.				
3	172	Dodballapur .	Shanbhoganhalli ...	490	960,120	2[illegible]	
4	227	Do	Bandamaranhalli ...	656	2,895,995	52	
6	225	Do	Bandamaranhalli Orrikere ...	315	405,566	39	
7	199	Do	Yalhkere ...	594	8,680,851	70	
			Total.....	2,055 or 3·21 sq. miles.	16,586,532 or 63·52 units.	169	

38. With reference to the surplus from tanks situated above the tanks comprised in the project, the statement marked B, annexed, shows pretty clearly that 853·785 m. c. ft could be anticipated during ordinary years, while during seasons of draught, the run-off would hardly equal the capacity of the several tanks.

39. From the foregoing it will be seen that the free catchment area providing the four tanks noted in Statement D are thrown out of action, amounts to 2·599 sq. miles, to which during years of minimum rain-fall, half the catchment area 1·41 sq. miles of the 12 tanks shown in Statement C should be added. This gives a free gathering ground of 3·04 sq. miles during the worst years which are really the only ones that need be considered with reference to the project, as during ordinary years the surplus from tanks above would be much more than sufficient to fill the whole of the tanks comprised in the project

40. *Run-off from Catchment.*—For the Rachenhalli project, Mr. W. De Vin'on has allowed 13 per cent run-off during a good year, which is equivalent to 0·935 m. c. ft. per sq. mile, from a rain-fall of 36."

Major S. Grant, R. E., assumes that the yield from the Mahgal catchment would be 13 per cent for a very bad year with a rain fall of 17"—25 per cent for mean year with a rain-fall of 36, and 40 per cent for a very good year with rain-fall of 56"—the run-off per sq. mile based on these assumptions would be 5·134, 20·503 and 52·039 m. c. ft.

41. The records of the Bangalore Water-supply Reservoir show that the run-off per sq. mile has been as follows —Minimum 7 m. c ft. average 11 m. c ft. maximum, 17 m. c. ft.—during the current year, which, notwithstanding the rain-fall, amounted to 27·03," is admitted to have been only the run off 11·598 m. c ft. per sq. mile=18·5 per cent.

42. Of the catchment area of 30·4 square miles, mentioned in para 38, the 3·12 square miles forming waterspread of tanks, and 12·4 square miles comprising land thrown out of cultivation below the Byata, Kakol and five other minor tanks will yield a run-off much greater than that from the catchment area of the Bangalore Water supply Reservoir; and considering that the remainder of the catchment area, consisting of dry cultivation, will be very impervious when the tank-filling rains fall in September, it may be accepted that the catchment area in question is similar to that of the Bangalore Water-supply Reservoir.

43. *Rain-fall*.—A statement comparing the rain-fall at Nelamangala, Doddballapur and Yelahanka, in the vicinity of the catchment of the Hessarghatta series, with that on the water-supply catchment area during the past three years is appended, but with reference to the same, I would here mention that the records of the three stations are incomplete and I consider untrustworthy.

Statement of rain-fall during 1890, 1891 *and* 1892 *on catchment area of Hessarghatta Tank and at Bangalore Water-supply Reservoir.*

Year.	Month.	Rain-fall in inches and cents.				Remarks.
		Sankey's Reservoir.	Nelamangala.	Doddballapur.	Yelahanka.	
1890.	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	·76	Nil	Nil	Nil	
	April	3·57	2·21	...	2·53	
	May	4 67	3·38	×	×	
	June	1 15	×	·10	×	
	July	4·02	2·22	1·92	1·94	
	August	6·95	6·16	...	3 33	
	September	3·70	3·37	1·92	4·02	
	October	3·81	...	4·98	8 65	
	November	5·66	2·39	7·42	6·38	
	December	Nil	Nil	Nil	Nil	
	Total.....	34 29	19·73	16 34	26·85	
1891.	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	·69	Nil	Nil	Nil	
	April	·28	Nil	Nil	·70	
	May	Nil	Nil	Nil	Nil	
	June	6·94	5·96	1 67	4·76	
	July	2·45	...	×	·85	
	August	2·30	×	3 34	1·41	
	September	·68	..	·51	×	
	October	5·94	×	4·20	4 30	
	November	·24	46	·25	13	
	December	·26	·30	·25	Nil	
	Total.....	19·78	6·72	10·22	12 45	
1892	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	Nil	Nil	Nil	·18	
	April	1·39	·98	1·15	1·84	
	May	4·08	5·39	2·90	1·71	* Yield from catchment 25·898 m. c. ft.= 11,598 m. c ft. per square mile.
	June	3·95	6·70	9·32	4·24	
	July	3·66	5·31	2 32	1·63	
	August	8·32	7·11	×	9·32	
	September	2·83	2 89	5·56	1·75	
	October	2·51	2·10	1 58	2·81	
	November	·29	90	·83	Nil	
	December	...	..	.	...	
	Total.....	* 27·03	29·38	23 66	23·48	

In places marked × thus, the returns have not been received.

44. From my knowledge, which extends over several years, of the country forming the gathering ground of the whole of the series, I think I may safely state that the rain-fall at Hessarghatta is similar to that at Bangalore, while in the vicinity of Nundydroog it is greater—allowing this, also that the catchment area is similar to that of the Bangalore Water-supply Reservoir, it follows that the yield mentioned in para 39 may be taken as the basis for calculation of annual supply.

45. *Yield anticipated from Catchment.*—During ordinary years, the supply from the catchment area would be 33·14 m. c. ft., which would not half fill the impounding tanks, but this is immaterial, as the surplus alone from tanks above in addition to this quantity would supply 303·668 m. c. ft more than the tanks will store.

46. The supply during a year of minimum rain-fall of 17″ would be 21·8 m. c. ft. and in the event of this occurring during the first year the supply of the station was started, the result would be that 245·655 plus 212·80 m. c. ft.=458·455 m c ft would be stored for use during the following year, and level of water in the Hessarghatta Tank would be 60·00

**Vide* para 32

Allowing a minimum rain-fall of 17″ during the second year, there would be 172·207 m. c. ft. stored for use at commencement of third year, as per details below:—

		M C. Ft.
Quantity in reservoir at end of first year		458·455
Percolation 15 per cent of quantity stored		68·768
Annual consumption at 500,000 c. ft per day		182·500
Evaporation allowing 6 ft. in depth per annum from mean area	$\frac{1,959 \quad 600}{2}$	= 247·780
	Total...	499·048
	Balance Minus...	40·593
	Add the yield for the year...	212·800
	Balance available at end of second year. .	172·209

47. The annexed Statement marked E shows the actual surplus from the Byata and Kakol Tanks and quantity lost by discharge over weir of Hessarghatta tank during the current year.

Statement E, showing surplus from Byata and Kakol Tanks and quantity lost by discharge over weir of Hessarghatta Tank during current year.

Month	Date	Kakol Tank weir, 202 feet. Depth of Discharge.	Quantity in c. ft. per minute.	Total for 24 hours.	Byata Tank weirs, 225 feet. Depth of Discharge.	Quantity in c. ft. per minute.	Total for 24 hours.	Hessarghatta Tank weir, 290 feet. Depth of Discharge.	Quantity in c. ft. per minute.	Quantity in 24 hours.	Remarks.
July ...	4th	1	1,997·04	2,875,737·6	June 28th 1′—2½ = 63,000 × 60 × 24 = 90,720,000. 29th 1′—3 = 71,525 × do 102,708,000. 30th 6 = 17,032 × do 24,526,800. July 5th 4′ = 9,270 × do 12,348,800. 9th 3 = 6,030 × do 8,683,200. Total c. ft.....238,986,800.			days-2 feet spillage on weirs = 605 × 60 × 24 × 290 × 8 = 2,021,184,000 c. ft. days-1 ft. do 214 × 60 × 24 × 290 × 7 = 625,577,400 do day-½ ft. do 75 × 60 × 24 × 290 = 31,320,000 do * 2,678,081,400			The whole of the sub series, with the exception of the Byata, drain into Kakol Tank. The combined catchment area is 89,205 acres and capacity of the tanks inclusive of capacity of Kakol Tank 2,493 units = 650·913 m. c. ft. and adding this to the quantity 935·489 m. c. ft. discharged over weir of Kakol Tank, the run-off from the whole catchment was 1,586·402 m. c. ft. equivalent to 11·3 m. c. ft. per square mile during 1892. Details of Hessarghatta Tank not kept. Taluk Amildar states there was a discharge of 2 feet over the weir for 8 days, 1 foot for 7 days and lastly half a foot. * Not reliable.
	5th	4	8,734·4	12,577,536							
	6th	8	24,698	35,565,120							
	7th	6	16,048	23,109,686							
	8th	3	56,773	81,753,981							
	9th	2	3,088·8	44,479,296							
	10th	1	1,091·8	1,572,192							
August ...	16th	6	16,048·4	23,109,696							
	17th	1	1,091·8	1,572,192							
	18th	[illegible]	386·5	556,[illegible]							
	19th	½	386·5	556,525·4							
	20th	7	20,220·5	29,117,606·4							
	21st	7	20,220·5	29,117,606·4							
	22nd	1	1,091·8	1,572,192							
	23rd	½	386·5	556,525·4							

	24th	½″	386·5	556,525·4								
	25th	4½′	10,415·5	14,998,406·4								
	26th	4½″	10,415·5	14,998,406·4								
	27th	3″	5,677·3	8,175,398·4								
	28th	1½	1,997·0	2,875,737·6								
September..	25th	4½	10,415 5	14,998,406·4								
	26th	9′	29,468	42,438,920								
	27th	11′	39,834·8	57,362,112								
	28th	8½′	27,051·2	38.954,728								
	29th	1½′	1,997	2,875,737 6								
	30th	36″	214,544	308,913,360								
October ...	1st	18″	82,892	119 361,480								
	2rd	12″	45,389·2	65,360,448								
	3rd	6″	16,048·4	23,109 696								
	4th	7½	224,296	32.298,624								
	5th	1′	1,091 8	1,572,192								
	6th	1	1,091·8	1,572.192								
	7th	½	386 5	556,525 1								
Total for year ...				935,189,371 c ft			238,986 800 c ft.			2,678,081,400 c ft		

Note.—Velocity of approach not known.

48. *Sanitary Condition of Catchment area.*—There are eight villages, particulars of which, with regard to population, &c., are given below situated in the vicinity of the margin of Hessarghatta Tank, and draining directly into it, and in addition to these, there are the villages of Byata and Kakol draining directly into the tanks of the same name :—

West of Arkavati valley, villages draining directly into Hessarghatta Tank.

Sonnainhalli	115 houses and 415 inhabitants.			
Chikdevanpura	...		...	
Basvanpur	57	„	246	„
Ramsandrapallya	...		.	
Kodinayakanhalli	...		...	
(Jodi village)	17	„	100	

East of Arkavati valley, villages draining directly into the tank.

Harohalli	42 houses		152 inhabitants	
Dasserhalli		„		
Gundajalli	82	„	234	„
Total...	313	„	1,147	„

Byata and Kakol villages consist of 150 and 107 houses and contain 522 and 331 inhabitants, so that the total population located in the vicinity of the Hessarghatta Tank is only 2,000, and I would submit that being so small, the removal of the villages is unnecessary; but better sanitary arrangements are requisite, especially in the villages of Byata, Kokal, Kodinayakanhalli and Gundahalli.

49. With regard to the necessity or otherwise of removal of villages, I would mention that in Fanning's—treatise on water-supply, it is stated as follows:—"About one-half the population of London, or one-half million persons received their domestic water-supply from the Thames in 1875."

Contours at R. L 65·00 since taken show that Ramasandra Palya and Chikdevanpur on the west of the valley and Herohalli and Gundahalli on the east will be on the margin of the tank, and these 4 villages must necessarily be removed.

"The drainage area above the pumping stations is about 3,675 square miles, and the minimum summer flow is estimated to be 350,000,000 imperial gallons daily and of this flow about 15,000,000 gallons is pumped daily by water companies. Upon the Thames water-shed above the pumping stations there resides a population of about 1,000,000 persons, including three cities of over 25,000 persons each, three cities of from 7,000 to 10,000 each, and many smaller towns and villages"

"The whole of the river and its principal tributaries are under the strictest sanitary regulations, which the Government is able to enforce, notwithstanding which a great mass of sewage is poured into the stream."

50. *Analysis of water*.—Specimens of water taken from the tank and from the sluice of Hessarghatta, Byata and Kakol tanks have been forwarded to the Chemical Examiner of Mysore, but analysis of same has not yet been received—the water in the Hessarghatta and Kakol Tanks appears to be good but that of Byata is rather discolored and probably contains vegetable impurities which must be due to the wet cultivation below the Amani Madhurai and Sheresandra Tanks having been extended into the bed of the Byata tank—this cultivation will I think cause much greater pollution of the water, than any that can arise from the small villages, and wet cultivation should I think be certainly prohibited within 100 yards of the margin of the whole of the tanks comprised the project.

Annexed.

HESSARGHATTA TANK.

PHYSICAL EXAMINATION—*Taken from the Tank.*

Color		Slightly cloudy
Smell		None
Taste		None
Reaction		Neutral
Lime		Present
Chlorine		A trace
Sulphuric acid		None
Nitric		None
Ammonia		Trace
Sulphuratted Hydrogen		None
Hardness Total	..	19 grs. of carbonate of lime per gal.
Permanent ..	..	13 6 chloride of calca (mainly.)
Removable ..	..	5·4
Organic matter		

Water taken from Sluice Cistern.

Almost precisely the same, only the amount of hardness both total and permanent is a trifle less, but nothing to speak of.

Opinion.—From the analysis I consider the water to be a good potable one it might be a trifle less hard, but the total hardness is nothing like sufficient render it unfit in any way for drinking purposes, it being just a trifle harder than the water in the Kukarhalli Reservoir at Mysore.

BYATA.

TWO SPECIMENS SENT.

A. Tank water.

Color	...	...	Faint cloud
Smell	...	...	None
Taste	...	..	None
Reaction		..	Neutral
Lime	.		Present
Chlorine	.		A trace
Sulphuric acid	...	..	Nil
Nitric	...	..	Nil
Ammonia	..	..	Nil
Sulphuratted Hyd.		.	Nil
Magnesia			A trace
Total Hardness	...		25 5 grs of Ca Co3 per gal
Permanent	..	.	18 5 Ca C—Magnesia salts
Removable	.		7 0
Organic matter	..	..	represented as
Chlorine	...		

Water taken from the Sluice

Almost identical with the above—only it is a trifle less hard

The water from the tank may be said to be a fair potable one and quite for use.

KAKOL TANK.

TWO SPECIMENS.

Water from the tank.

Color	..	White
Smell	...	Slightly earthy
Taste	...	None
Reaction	...	Neutral
Lime	...	Present
Chlorine	...	A trace
Sulphuric acid	...	Nil
Nitric	...	Nil
Ammonia	...	Nil
Sulphuratted Hyd.	...	Nil
Magnesia	...	Trace
Total hardness	...	15·40 grs. of Ca Coz per gal.
Permanent	...	13·30 Ca C 1 Magnesia salts
Removable	...	2 10 Ca Coz
Organic matter		

The other sample is precisely the same. This water is by far the best of the 3 samples sent.

In the event of these tanks being used as a water scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably better than it is at present.

(Intd) P. H B.

---

51. (A) *Brief description of project.*—It is proposed to impound 883·462 m. c. ft. of water in the eight tanks mentioned in para 28, and to deliver the same at the rate of 500,000 c. ft. per day into filter and service reservoirs located on the Mantapam Hill to the north of Bangalore.—(B) At Hessarghatta Tank a water tower will be constructed with valve at M. S. L. 2,796·84, from which water will be led by means of covered masonry channel 23,826 feet in length with a fall of 1 in 5,000 to settling reservoirs located close to a pumping station situated a short distance from the Bangalore-Tumkur branch of the Southern Mahratta Railway, half a mile north-west of the village of Banawar.—(C) From the pumping station the water will be raised to a stand post 42 feet in height constucted on the top of the Banawar Hill, the M. S. L. of which is 3,097·64.—(D) From the stand-post the water will be delivered in a cast iron Main, 24″ diameter by gravitation into filtering cisterns and service reservoirs, the combined capacity of which will be equal to five days' supply.—(E) The floor of service reservoirs to be at M. S. L. 3,055, which will give a sufficient head for an economical distribution to the Cantonment and City of Bangalore, the former of which being so widely scattered a maximum head is indispensable, unless the higher portions of Bangalore are provided with a separate service, which it is quite possible might prove to be the most economical.—(F) From the storage reservoirs service mains would be taken, one in a direct line to the Bangalore District Office for the City and the other to the Cantonment Railway Station, from which branches could be taken off for supply of northern and southern portions of Civil and Military Station.

52. Prior to entering into details of cost, &c., of the several items of work, I would here remark that the project is analogous to that referred to by Colonel H. M. Vibart, R. E., in paras 2 and 3 of his letter No. 2946, dated 20th October 1887, to the Chief Engineer, Madras Public Works Department (*vide* page 247 of Memorandum of Bangalore Water-supply) with reference to which, I would state that I have recently investigated a project (details of which are given below) for the construction of a dam across the Arkavati river, at a site situated 2½ miles below the bridge on the 12th mile of Salem-Bellary road, for irrigation of 2,000 acres of land on both banks of river; regarding which, it is only necessary here to mention that construction of a dam impounding more than 154·310 millons c. ft. of water is impracticable without endangering the safety of the Southern Mahratta Railway bridge across the same river.

Mean sea level of bed of river at proposed site of dam	...		2,718·56
Do of crest of dam	...		2,74·56
Quantity of water impounded	...		1,543·10 M. c. ft.
Cost of dam...	...	Rs.	40,451
Cost of raising road bridge 15 ft. ...	..		16,506
Probable amount of compensation for land submerged	.		8,940
Contingencies at 5 per cent	..		3,297
	Total	Rs.	69,254

STATEMENT OF PROBABLE COST OF PROJECT.

53. *Head works.*—Raising weir of Hessarghatta tank 15 ft. in height.

Constructive Details.

Weir on left flank at R. L. 2,819 17 and 300 feet in length.
Bund to R L. 2,829·17 with top width of 15 ft. front slope 1½ to 1 and rear slope 2 to 1.
Revetment at R. L. 2,825·17.
Cill of sluice at R. L. 2,796·84
Area (approximate) of waterspread at 2,819·17=1,702 acres.
Capacity at R. L 2,819·17=2,116½ units=767·337 m. c. ft

(*a*) *Bund.*—The right flank will be in continuation of the present cross bund, constructed during 1877. On the left flank, a cross bund will be taken off at bend in bund, at a distance of 330 yards from the present weir (See C. S. No. 5 on plan) and from thence will be continued to the High Ground, where it tails off at R. L. 2834·57.

							Rs.
Earthwork	167,154 C. Yds.	at	3 As.	per	yard	...	31,341
do	11,988	do	1½	do	do	...	1,124
Old stone revetment	2,190	do	10	do	do	..	1, 69
New do	16,356	do	1¼ Rs	do	do	...	20 ,45
Old stone do	1,118	do	12 As.	do	do	...	899

(Stone to be taken from the abandoned portion of bund on right flank)

Removal of right sluice and re-lling bund	L. S.	300
Ring bunds at sluices while undergoing removal	L. S.	500
Repair of left sluice to allow of cultivation of garden land from water impounded between new and old weirs	L. S.	500

Puddle trench and wall.—

	As.	Rs.	
Excavation 14,988 C. Yds. at 1½		1,405	Rs. 9,591
Puddle wall 26,196 C. Yds. at 5		8,186	

Total for Bund Rs.....66,069

(*b*). *Waste Weir.*—It is propsed to repair and retain the present weir and to construct another weir above it, in the new bund on the left flank, as per plan—the crest will be at R. L. 2,819·17 and toe at R. L. 2,791·79—the weir will consist of a masonry body wall with wings, masonry binding walls 39½ feet apart in apron, and toe wall the apron being sujikat of the best quality 1 yard in depth.

			Rs.	A.	P.		Rs
Brick in chunam ...	17,802 C. Ft.	at	0	3	0	per C. Ft. ...	3,338
Plastering with mortar .	31·05 Sqrs	at	3	0	0	per square ..	93
Sujikat	6,014 C. Yds.	at	1	8	0	per C. Yd. ...	9,021
Earthwork, cutting approach to weir... ...	*6,188 C. Yds.	at	0	1	0	per C. Yd. ...	386
Do do for apron, &c.	64,253 „	at	0	2	0	do ...	8,032
Do do draught channel from the weir ...	*1,46,300	at	0	1	0	do ..	9,144
Revetment to sides of apron and of draught channel above and below weir.	1,160 C. Yds	at	1	4	0	do .	1 450
Stone slabs 8 at 8 a_ s per S Ft	4,1 9	...				.	2,0

Total for new weir Rs.....33,513

* * to be used for bund.
* * Earth to be used for bund at rate of 4 annas per C Yd. which will reduce the rate of earth work for weir to one anna per C. Yd

								Rs.
(c) *Repair of old weir*—				Rs.	A.	P.		
Brick in chunnam	...	3,444 C. Ft.	at	0	3	0	per C Ft. ...	646
Plastering with mortar	...	21 65 Sqr.	at	3	0	0	per Sqr. ...	65
Pointing with Portland cement		22 16 Sqr.	at	5	0	0	do ...	111
Old stone sujikat 46 C Yds.		...	at	0	10	0	per C. Yd. ...	29
Sujikat apron 350 do		...	at	1	8	0	per do ...	525
Stone slabs 8′ × 454 S. Ft.		..	at	0	8	0	per Sqr. Ft ...	227
Jelly packing to apron	..	1,245 Sqr. Yds	at	0	1	6	per Sqr. Yd. ...	117
Petty jobs	...	... Lump sum					... ...	100
Blasting	...	..	do				.. ..	150
Earthwork	...	...	do				... ...	50

Total for repair of work Rs.....2,020

54. *Water Tower*:—

(A). It was first proposed to take off the delivery channel through the left flank of the new cross bund, at a short distance from the weir, and to follow the left bank of the river; but longitudinal section taken along this line shows that it is impracticable, as the ground is cut up into numerous ravines, across which it would be impossible to construct a water-tight channel except at a very heavy outlay, and moreover for upwards of half a mile, the channel would be below flood level of river (*see* Sheet No. 12).

(B). In accordance with the Chief Engineer's instructions, given on his inspection of the tank, sections were taken along the right slope of the old abondoned bund of tank (*see* Sheet 13). A delilvery channel along this line is practicable, but would prove very costly, as two breaches (one of which is a very large one) in the old bund would have to be filled in, and an aqueduct 200 feet in length would be required where the channel necessarily crosses the river.

(C). The cost of filling in breaches would amount to Rs. 2,680 and that of aqueduct to Rs. 3,275, in addition to which a sum of Rs. 191 would have to be expended on excavation—the total outlay would thus amount to Rs. 6,146 which, although very heavy, would not be prohibitive, were it not that the aqueduct would be insecure—the flooring of the delivery channel being only ·35 feet above flood level in river, which would necessitate placing the under surface of girders at least ·77 feet below that level.

(D). The above mentioned lines being practically not feasible, another line was selected, which skirts the left end of proposed cross bund and then passes along the high ground at a short distance above the first line, quite clear of all ravines (*see* Sheet No 14).

(E). The excavation will be from 14 to 24 feet in depth, but cost of same (Rs. 2,619) is much less than the cost of filling in the breaches and construction of aqueduct on the second line, and the alternative line, shown on Sheet No. 14, is, I think, the only practicable safe one.

(F). The alignment of the delivery channel being necessarily outside of the weir, the water tower must of course be in a similar situation, and site selected is the margin of the present water-spread, at a distance of 600 feet above the new weir, and well out of line of draught to it.

(G). The water tower will be similar to that constructed at the Bangalore Water-supply Reservoir (*vide* Sheet No 17), the only exception being that valves will be placed at sluice openings, instead of wooden shutters.

(H). The tower will be octagonal 6 feet internal and 15 feet external diameter with vents at R. L. 2,796·84—2,804·28 and 2.811·72. and top at R. L. 2,823·17, or 4 feet above crest of weir.

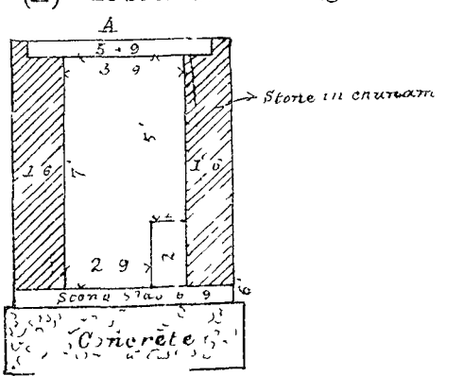
(i) A tunnel 676 feet in length will be constructed from the water tower, in which a 30′ cast iron flanged pipe laid at a slope of $\frac{1}{1000}$ will be fixed, and fitted with valves in water tower and at end.

55. The approximate cost of the work is as follows:—

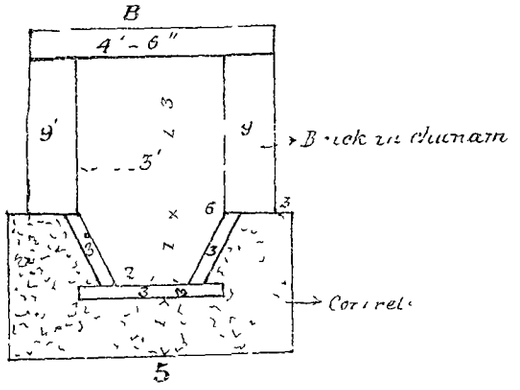
		C. Yds.		Rs.
(A)	"Earthwork"—			
	Excavation for open channel to water tower	622		
	Do for tower ...	1,648		
	For tunnel from tower ...	16,052		
	Total.....	18,322	at 2 as 6 p. =	2,863
		C. Ft.		
(B)	Concrete in Surki—			
	For foundation of tower 18½ × 18½ × 2' =	684		
	Do of tunnel 750 × 13 × 2 =	19,500		
	Superstructure of towers	5 660		
	Total.....	25,844	at 3 as. 3 p. =	5,250
(C)	Stone in Surki mortar—			
	For foundation of tower	919		
	Do of tunnel	19 500		
	Superstructure of tower .. .	1 300		
	Total	21,719	at 3 as 3 p =	4 412
(D)	Cut stone work—			
	For tower... ...	788	at Re 1 =	788
	Dressed Quoins... Sq Ft.	1278	at 4 as =	319
(E)	Brick in Surki mortar—			
	Ventilating shaft ..	1148		
	Side walls of tunnel ...	11 250		
	Total.....	12,398	at 3 as. 3 p =	2424
(F)	Archwork in Surki mortar—			
	For tunnel	2 000	at 6 as. =	775
(G)	Stone Slabs 8 dressed—			
	For floor of tower Sq Ft	157		
	Do of tunnel .	6,375		
	Total.....	6,532	at 12 as =	4,899
(H)	Cast iron flanged piping 30 diameter and 1 thickness of metal—			
	50 R. ft. weighing 2·65 cwt. per feet run 119 cwt at Rs. 9—8—0 per cwt.		=	1,412
(I)	Carriage to site and fixing—			
	50 R ft. at Rs 1—8—0 per R ft.		=	75
(J)	Valves 30 double faced with gun metal (inclusive of carriage, &c)—			
	No 5 at Rs. 750 each		=	3750
(K)	Open channel as per section in margin—			
	700 R ft at Rs. 3 per R. ft		=	2,100
	Total cost of water tower.....			25,760

56. Delivery Channel.

(A) To be of section A (given in margin) from end of tunnel of water to [illegible] (vide sheet No 11) where it falls off into low ground with ventilating shafts and silt traps at every ten chains.



(B) From the 54th chain, the channel will be of section marked B, with acqueduct at drainage crossings as mentioned in the subjoined report, and silt traps at every ten chains—the fall throughout will be $\frac{1}{5000}$ and both sections of channel will discharge more than the required quantity (5·787 cubic feet per second) when flowing 2 feet in depth.



(C). The channel as now aligned is very crooked, and, in addition to the alteration in the first 54 chains, several other deviations will be necessary, the principal being on chains 72 to 120, from chains 162 to 178 and from 270th to 305th.

(D). From 54th chain to 83rd chain the channel passes through dry cultivation, at 83rd chain it enters gardens, and continues in these up to 108th chain; the crossing of the kodi nala of Aivardanpur Tank is at the 99th chain where floor of channel is at R. L. 2,792·34 and bank of nala (which is frequently topped) at R. L. 2,796·89.

(E). This portion of channel (from 72nd to 120th chain) must be altered and longitudinal section of deviation is given in Sheet No. 15 from which it would be seen that the length of the channel can be decreased by 2,446 feet; the channel will be raised above the level of the ground for a distance of 688 running feet, and some arrangements will have to be made for irrigation of land lower down the valley, as the present earthen dam across kodi channel, by means of which irrigation is now carried on must be removed, the cost of such work will, however, be more than counter-balanced by saving in length of channel.

(F). From 120th chain the channel runs close to Aivardanpur irrigation channel up to 126th chain, from whence it turns to the left and runs through dry cultivation up to 162nd chain, where it enters the wet cultivation below the Huchuchakenhalli Tank; from 162nd to 178th chain the channel crosses this wet cultivation, and alteration of alignment will here be necessary, which will decrease the length of channel by 528 feet—the whole length of the channel (528 feet in length) of this re-alignment must be carried above ground level.

(G). From 175th chain to 241st chain the channel runs through—dry cultivation—from 241st to 250th through black cotton soil, where an alteration of alignment is necessary—from 250th to 289th the channel passes through dry cultivation, and from this point it follows the Railway up to 317th chain—from 270th to 305th chain the alignment should be altered and a further saving in length of over 6 chains can be made.

(H). At 305th chain the channel leaves the Railway and runs to the left, passing over very broken ground between 330th and 332nd chains and crossing the kodi nala of Kumbarhalli Tank at chain No. 335—the channel between 330th and 362nd chains should be carried higher up and kodi channel should be crossed 200 feet above present crossing. (An acqueduct 20 feet in length will be wanted across the Kumbarhalli drainage.)

(I). From 352nd to 376th chains the line of channel runs through the wet cultivation below the Kumbarhalli Tank and at 380th it crosses the combined kodi nala of the Banavar and Ganigarhalli Tanks. An acqueduct 50 feet in length is here necessary.

(J). At 385th a rather deep nala is crossed, but a little higher up, it tails off, and lower down forms an irrigation channel; consequently all that is necessary is to throw up a dam across it and construct a tunnel for irrigation on the left bank.

(K). From 386th chain the ground rises rapidly on all sides, and the channel cannot be continued beyond the 390th chain without necessitating deep cutting, which would add greatly to the cost of the settling reservoirs which are proposed to be placed at end of delivery channel.

57. Approximate cost of delivery channel: –

		C. Yds.	Rs
(a)	Earthwork excavation and refilling—		
	For first 660 feet from end of Channel up to line with weir	17,954	
	Beyond line of weir up to commencement of chain No. 1—1056 feet	24,562	
	From 1st to 50th chain 3,300 R ft	20,955	
	Total 63,471		
	At As. 3—6 =		13 884
(b)	Delivery channel as per Section A— From end of tunnel to 50th chain 5,016 R. ft. at Rs. 10—6 =		5.. 041
(c)	Ventilating shafts and silt traps— From end of tunnel to 50th chain No. 8 at Rs 175 ... =		1,400
(d)	Delivery channel as per sketch B. 18,810 feet at Rs. 4 ... =		7 ,240
	Fencing line and drainage 4·51 miles at Rs. 300 per mile ... =		1,353
	Compensation for lands, 12 acres at Rs. 35 ... . =		420
	Aqueduct—		
	No. 4 aggregating 1278 R. feet inclusive of cost of channel at Rs. 4 per R. feet .. .. =		5,112
	Silt traps—		
	One at every 10 chains, No. 34 at Rs. 10 .. ... =		340
	Total cost of delivery channel		1,49.790

58. *Settling tanks.*—At the end of delivery channel it is proposed to have two settling tanks, each to hold a day's supply. The tanks will be 211 feet square at bottom and 10 feet in depth with slopes of 1 to 1, and will be floored and lined with $1\frac{1}{2}$ feet of brick in surki, plastered throughout with surki mortar

The site selected for the construction of tanks is a favorable one, there being four feet of "red soil" with clay underlying it.

The cost of the work will be as follows:—

	Rs
Earthwork excavation 21,876 C yds. at As. 2 = ...	3 181
Brick in surki 68,854 C. ft at Rs. 3=	16 6??
Plastering with surki mortar 592 36 sq at Rs 3	1?.7
D. Pumping well, constructed with Portland cement L. S.	150
E. *Land*	
2 acres at Rs. 36	
Total Rs..	22 1?5
For two tanks Rs	11?6

59. *Pumps and Engines.*—(A.) Will be fitted up immediately above the settling ponds at a distance of 150 yards from the Southern Mahratta Railway line.

(B.) Allowing 24 as maximum diameter of pipe main and that it is necessary, with reference to economy in cost of distribution, to have the floor of service reservoir at R. L. 3,055, the lift will be 357 ft. as per details below.

(C.) Level of service reservoir . . . . R. L. 3,055·00.

Head necessary to discharge 500,000 C. ft. in a day of 13½ hours in 24" piping, the length of main being 36,960 ft		74·00
Loss in filtering and service reservoirs		10 ft.
	R. L. ...	3,139 ft.
Floor of Settling Tanks R. L		2,782 ft.
	Difference...	357 ft.
Pumping main 8,580 feet in length, 24' diameter, to discharge 617·3 C. ft. per minute head required		17 ft.
	* Total Lift...	374 ft.

(D.) The Agent of the Worthington Pumping Company, Calcutta, has been addressed regarding cost inclusive of delivery and erection of two triple expansion engines with Babcock boilers, each engine to lift 3,858 gallons per minute to a height of 374 ft. through 1¾ miles of 24" rising main: and on receipt of † reply, the actual cost of this sub-head of work will be given, but in meantime to allow of completion of approximate estimate, a sum of Rs. 2,00,000 has been allowed.

(E.) In order to reduce the lift as much as possible, pumping for 13½ hours per day has been allowed; but, as in any case relays of men would be necessary, this as well as the additional pumping of 7 hours twice per week, necessary to keep up the supply and allow of a day's rest on Sundays can be done without difficulty.

60. *Rising Main.*—

(A) Will start from the 398th chain and be laid in a straight line to the top of the Banavara Hill, (517th chain) where it will be joined on to the stand post—at the 416th chain. The line of piping crosses a nala, 50 ft. in width and 8 ft. in depth, from whence up to the Railway (421st chain) it runs over broken ground—the line crosses the Railway diagonally at Telegraph post 200—191, where it is in cutting 4 ft. in depth, and a tunnel will be necessary—at the 442nd chain the line of piping crosses two ravines, and will have to be carried on masonry pillars for the distance of two chains—from this to top of hill there is not any obstruction of much consequence.

(B) The main will be of 24" socket and spigot piping and 8,580 ft. in length. The thickness of the piping being 1 inch, the weight inclusive of socket will be 2·37 Cwt. per ft. run.

85,80 × 2·37=20,334 Cwt. at 7—12—0	1,57,588

* Deduct 20 ft. for suction.

† Telegram despatched and reply to following effect received —
"We can only quote for high pressure and compound, all triple expansion made under royalty by "S. Simpson & Co, London'

In reply to subsequent telegram asking for quotation for compound Engines, the Agent telegraphed—
"We have cabled for special quotation and will wire you on reply."

C. *Laying Pipes.*—

8,580 R. ft. of 24" piping at Rs. 1	8,580
Grand total of rising main..	166,108

61. *Engine and Boiler house with Chimney.*—

Lump sum	20,000

62. *Quarters for Establishment.*—

Lump sum	16,000

63. A. *Stand-Post.*—To be 42 ft in height above top of Banawar Hill, the R. L. of which is 3,097·64

B. Flanged pipes 24' diameter and 1½" thickness of metal to be used. Special castings throughout will be necessary, as bends at base must have proper seating and flanges of piping must have lugs.

C. For 30 ft. in height the stand-post will be carried up in a masonry tower, which will serve as a watchman's post and signalling station: consequently struts and braces will be requisite for the upper 12 ft. only

64. *Details of cost*—

Tower 8 feet octagonal.

A.	Stone in chunam foundations	256 ft.
	Basement	57
	Superstructure	1,282
	Total...	1,595 C ft
	at As. 3—6 =	Rs. 349
B.	Doors and Windows	Rs. 50
C.	Roofing slabs and Terrace	Rs 30
D.	Ladder with trap doors	Rs 50
	Total	Rs. 479

E. 24" flanged piping.
F. 68 feet straight pipes with special flanges 30 ft of bends, &c.
Total 98 ft. 2·75 Cwt. per ft = 269½ Cwt. at Rs. 10—8 Rs. 2,830

Fixing piping 98 ft. at Rs 2 ..	196
Grand Total, Rs ..	3,505

65. *Delivery Main*—A There is a marshy dip just beyond the brow of the hill, but this can to some extent be avoided by a slight deviation to the west.

B. At 783rd chain the line crosses the Southern Mahratta Railway and at 893rd chain, the Bangalore-Hindupur-Railway—from 86 th to 89 th chain, the line passes through the bed of the Yesvantapur Pond and no deviation will I think be necessary on this account as the soil in bed of tank is hard and clayey

C. The total length of rising main in which the pressure is just equal to the head is less than 110 feet and consequently a light pipe has been made use of this as the limit that can be allowed with regard to safety of carriage.

66. *Cost of Main.*—

36,960 R. ft of 24" piping with 1" thickness of metal weight 2·37 Cwt. per ft. run—87,595 Cwt. at Rs 7-12 0 per Cwt. Rs. 6,78,861

			Rs.
B.	Laying pipes 36,960 R. ft. at 1 Rupee per ft. =		36,960
C.	Air valves 5 at Rs 200		1,000
D.	Scour valves 6 at Rs. 150		900
E.	Sluice valves 4 with spigot and socket faced Tail Pipes at Rs. 520		2,080
F.	Reflux valves 6 at Rs. 500		3,000
	Grand Total for Delivery Main...		7,22,801

67. *Filtering Reservoirs.*—

A. Will be similar in construction to the settling tanks, *i. e.*, reservoirs sunk below ground level, floored and lined with 1½ ft. of brick in chunam.

B. Three each 144 ft. square, two of which will filter a day's supply at the rate of 75 gallons per sq. ft. in 24 hours.—The filtering strata to consist of sand, charcoal and stone jelly 2'—6"—4" and 1 ft. in depth respectively.

68. *Cost of Reservoirs*—

A. Earthwork excavation—

		Rs
11.271 Cubic yards at 2 annas	... ...	1,409

B. Brick in surki mortar—

47 109 C. ft. at 3 annas	.. ...	8,833

C. Plastering with surki mortar—

399 7 Squares at Rs. 3	... ...	1,197
	Total.....	11 459
	For 3 Reservoirs.....	34,317

69. *Service Reservoirs*—

A. Construction to be similar to that proposed for filtering reservoirs, with the exception that it will be covered with stone slabs carried on stone pillars 1 ft. sq., fixed 9 ft. apart from centre to centre, which will be founded on stone slabs, laid 1½ ft. below foundation of floor of reservoir

B. Reservoir to be 10 ft. in depth and to store 3 days' supply or 1,500,000 C. ft.

70. *Cost of Service Reservoirs*—

A. Earthwork Excavation—

		Rs
72,150 C. Yds. at 2 annas	... ...	9,019

B. Brick in Surki—

277,200 C. ft at 3 annas	... ...	51 978

C. Plastering with surki mortar—

1882 80 Sqs at Rs. 3 per Square	... ...	5,648

D. Stone slabs for foundation of pillars—

12,420 Sq. ft. at 3 annas	... ...	2,329
	Carried forward.....	68,974

Brought forward... Rs. 68,974

E. Stone pillar 14′ × 1′ × 7″ (dressed)—

	Rs.
No. 2,070 at Rs. 5	... 10,350

F. Stone girders 9′ × 1′ × 8″—

No. 2,000 at Rs. 3—8—0 ...	... 7,000

G. Stone slabs (9 × 1½′ × 4½″) sides dressed —

186,979 Sq. ft. at 3 annas ...	... 35,059
Grand Total.....	1,21,383

71. *Distribution* —

Rupees 3½ per head for population of 250,000 ...	8,75,000

72. *Compensation.*—

A. Land thrown out of cultivation below Hessarghatta Tank—

	Rs.
Wet land 202½ acres at Rs. 75	... 15,187
Garden land 110½ do 100	... 11,050
Total.....	26,237
Deduct probable receipts by sale of land for dry cultivation, 313 acres at Rs. 36 . ..	11,268
Net compensation to be paid ...	14,969

B. Land thrown out of cultivation below Byata Tank—

Wet land 75½ acres at Rs. 75	.. 5,662
Garden land 10½ do 100	... 1,050
Total.....	6,712

Land thrown out of cultivation below Kakol Tank—

Wet land 123¾ acres at Rs. 75	... 9,281
Garden land 11¼ do 100	... 1,125
Total.....	10,406

C. Land submerged by raising weir of Hessarghatta Tank—

Wet land—see statement of wet land below Byata and Kakol tanks—dry land *643 acres at Rs. 36 per acre	23,148

* In addition to this 158 acres of wet lands now lying fallow below the Byata and Kakol tanks will be submerged.

† Details for the five minor tanks cannot be given as Revenue statements for same have not yet been received from the Revenue authorities.

† Revenue statement for four tanks since received.

D. *Somanahalli.*—Land thrown out of cultivation—

	Rs.
Wet land 44 acres at Rs. 75	.. 3,300
Garden land 2 do 100	... 200
Total.....	3,500

E. *Chik Devanpur*—

Wet land 28 acres at Rs. 75 .. .	... 2,100
Garden land 2 do 100	... 200
Total.....	2,300

Carried over . Rs. 61,035

Brought forward...Rs. 61,035

F. Devarakunte Tank—

	Rs
Wet land 25 acres at Rs 75	1,875
Garden land 6½ do 100	650
Total.....	2,525

G. Arasinkunte—

Wet land 19½ acres at Rs 75	1,462
Garden land 1½ do 100	150
Total.....	1,612

H. Jumbinkunte—

Wet land at Rs 75	
Garden do 100	
Grand Total.....	65,172

73. *Loss of Revenue*—

Particulars with regard to this item can only be given for the Hessarghatta, Byata and Kakol Tanks, as Revenue statements for the five minor tanks have not yet been received, notwithstanding several reminders have been sent to the Revenue authorities on the subject *

Hessarghatta Tank—

	Rs
Wet land	1,216
Garden land	628
Total....	1,844

Byata Tank—

Wet land	493
Garden land	78
Total.....	571

Kakol Tank—

Wet land	792
Garden land	51
Total.....	843
Grand Total.. ...	3,258
Deduct probable revenue from land below Hessarghatta Tank, if leased as dry land, 313 acres at Rs 2	626
Net Loss.....	2,632

Sonnainhalli—

Wet land	220
Garden land	15
Total.....	235

Chik Devanpur—

Wet land	142
Garden land	19
Total.....	161

*Since received for other tanks.

Devarakunte—

		Rs.
Wet land	... ...	112
Garden land	... .	12
	Total.....124	

Arasinkunte—

Wet land	... ...	82
Garden land	... ...	3
	Total...85	

Jumbinkkunte—

... ...	...	...
... ...	...	...
	Total.....	
Add loss of Revenue on 4 tanks noted above ...		605
Do 643 acres of dry land submerged		965
	Grand Total... ...4,202	

74. *Abstract of Cost of Project.*—

Present value of 8 tanks comprising project (See Statement page 19)	1,04,795

Head works—

Bund	66,069
Waste weir	33,543
Do	2,020
Water tower	37,760
	2,44,187

Delivery works—

Masonry channel	1,49,790
Settling Tanks	14,286
Pumps and Engines	2,00,000
Rising Main	1,66,168
Engine and Boiler house with chimney ...	20,000
Quarters for establishment .. .	16,000
Stand post	3,505
Delivery Main	7 22,801
Filtering reservoirs	34,317
Service reservoirs	1,21,383
Town distribution	8,75,000
	23 58,250

Incidental charges—

Compensation for land	65,172
Contingencies at 5 per cent	1,29,871
Establishment 15 per cent on Head works, masonry channel, settling tanks, engine and boiler house quarters for establishment, Stand-post, filtering and service reservoirs	95,020
Establishment 5 per cent on other items ...	98,198
Grand Total.. ...Rs.	29,85,698

R. T. SCALDWELL,
Executive Engineer, Bangalore Division.

10th January 18

Mysore Govt, Central Press, Bangalore —19-2-93 —50

3,806 = 4.2 M

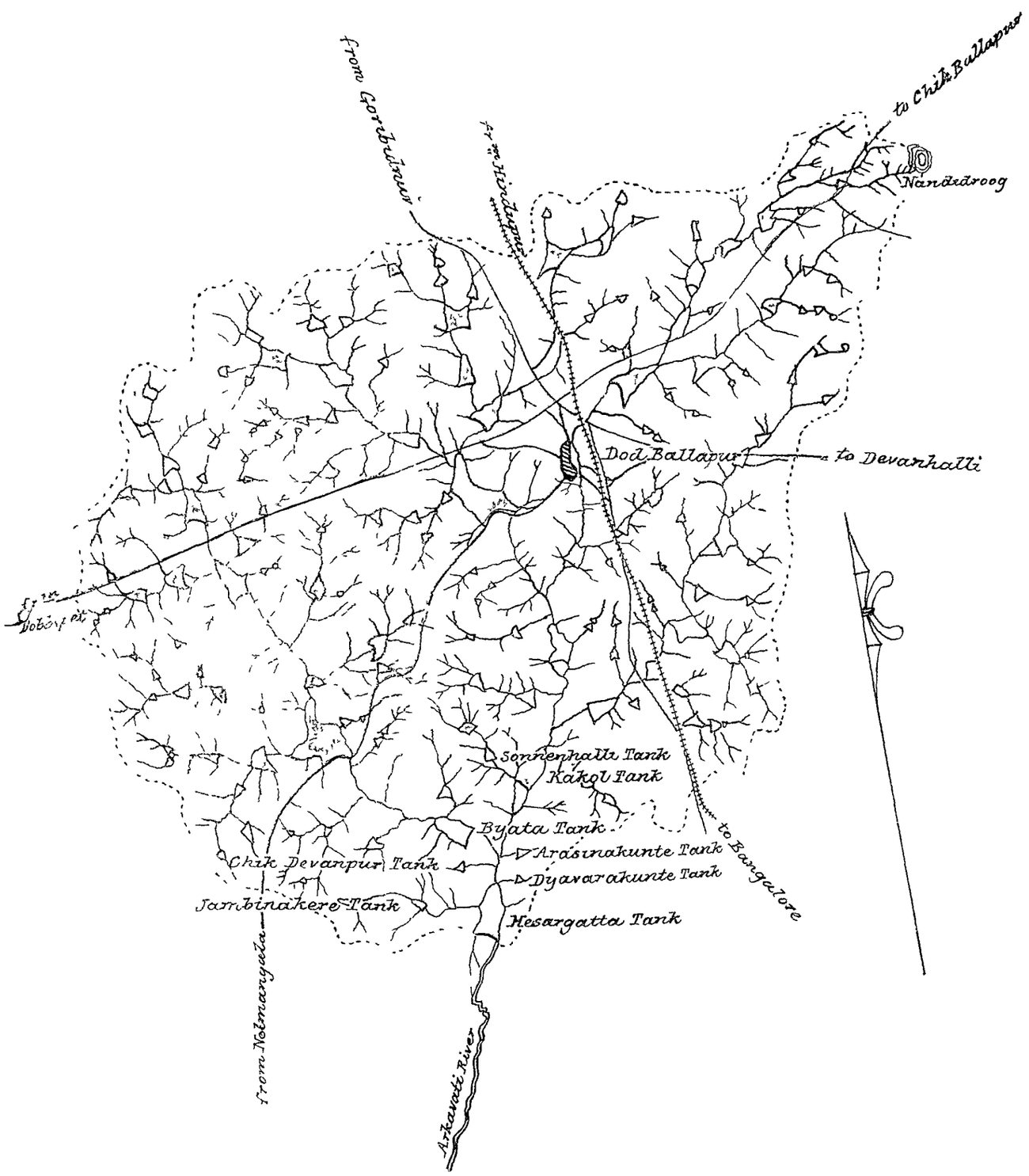
[illegible]0 = 1.6

[illegible]6 = [illegible]

1301. M

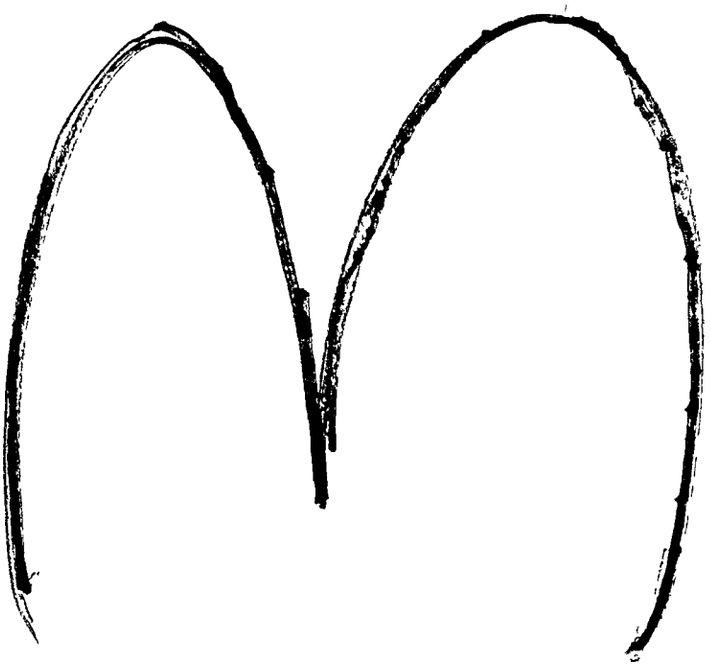
HESARGATTA TANK SERIES

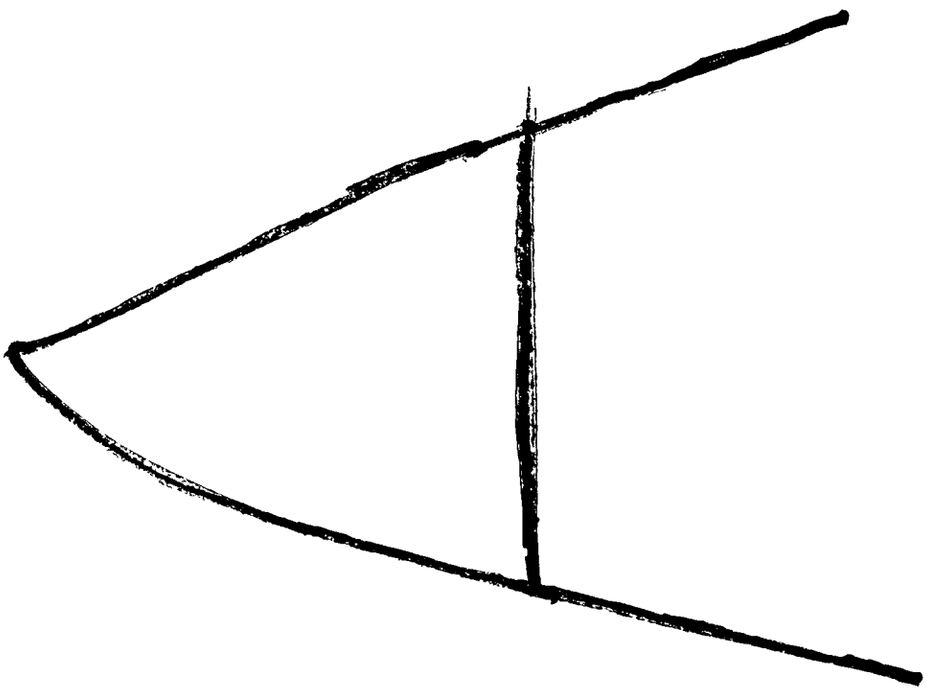
Scale 1 Inch = 3 Miles



No of Tanks 187

Catchment area 212 Sqr Miles





Dewans Note on the Hesarghatta Scheme of Water-Supply to the Civil and Military Station as well as to the City of Bangalore

---

[1 Report by Mr. Scaldwell Executive Engineer of Bangalore, dated 10th January 1893

2 Preliminary report by Colonel D. McNeil Campbell, Offg. Chief Engineer in Mysore dated 26th January 1893]

Supply required.

1. In my note of the 31st October 1892 directing the investigation of this Scheme, I laid down that the project should provide a supply sufficient to last for 3 years for a population

population of 2,50,000,
at the rate of 2 cubic
feet per head per day.
Colonel Campbell re-
-commends a some-
-what reduced supply
namely, that for a po-
-pulation of 200,000 at
10 gallons a day. The
present combined po-
pulation of the Station
and the city accord-
ing to the Census of
1891 is 180,000 being
an increase of
nearly 15% per 1000 on
the population of 1881.
We

We may reasonably anticipate a more rapid increase of population, as the result of an established water Supply and the Connection, now approaching completion, of our Railway System with the East Coast Railway. I therefore think it unwise to provide for less than a population of 250,000. I think it would also be a mistake to give less than 2 cubic feet

per head per day.
It is true that the
people will for some
time continue to re-
-sort to existing sources
of supply and that,
as long as they do so,
it might be sufficient
to allow 10 gallons per
head. But these exist-
-ing sources in Bauga-
-loe are of a nature
likely utterly to fail
in exceptional sea-
-sons like the present
and when such
failure happens the
entire

entire supply would be drawn from the proposed system. It is therefore necessary that the Scheme should provide a full supply About 2 Cub. ft. a day is supposed to be the minimum quantity required for the troop and though half that quantity has in some quarters been held to be sufficient for the Indian Section of the population, yet the habits

habits of the latter — are not such as would justify the — proposed difference of treatment. I would accordingly assume the supply required at 2 cub. ft. per day per head for a popu- lation of 2,50,000 and upon this basis work out the details of the scheme to be immediately carried out.

2. In my note of 31st October 1892, I proposed

Storage Reservoirs required.

proposed that the
Waste-Weir of Hesar-
-gatta which is the
terminal tank across
the Arkavati river,
should be raised 15,
and those of the 2 tanks
above it, viz Kakol
and Byata, should
each be raised 6 ft.
Mr. Scaldwell's report
shews that the proposed
enlargement of Kakol
and Byata would be
attended with undue
risk and expense and
that it would be
sufficient

sufficient for the —
practical require —
ments of the Scheme
to include in it the
nine minor tanks —
named by him. This
proposal being ac —
— cepted, we need only
enlarge the capacity
of Hesarghatta by —
raising its Waste-Weir
15 ft. leaving Kakal,
Byatra and the nine
minor tanks above
referred to, as they now
are. Thus for purposes
of Storage the Scheme
will comprise the 12
tanks

Tanks of which particulars are given below

No.	Name of tank	Mean sea level of waste weir.	Free catchment area in acres	Area of water spread in acres	Capacity of tank in millions cub feet.
1.	Hesargatta.	2804·17	4405	336·53	89·556
2.	Byatta.	2835	4954	157·59	22·987
3	Kakol.	2834	2553	320·55	79·896
4	Sonnenahalli.		401	18·97	3·113
5	Chikdevarpur.		463	16·86	2090
6*	Jembankere.		990	38·44	6·263
7	Arsinkunte.		498	14·40	1·082
8	Devarkunte.		318	16·84	1·749
9	Shanbhoganhalli		490	7·32	0·960
10	Budamanhalli		656	22·14	2·894
11*	Arikere.		315	3·11	0·406
12	Yettikere.		594	66·40	8·681
	Total.		16637 + or nearly 26 sq. miles	1019·15	219·677
	Add water spread capacity due to enlargement of Hatta to mean sea level 2819·1 4 — raud.			1365·47	677·781
				2384·62	897·458

Nine minor tanks

* To this channel we added 4·42 sq. miles being half of the particularly free catchment area of certain other tanks (Vide Mr. Lewis's report, Para 39)

area available.

3. The reports give full information regarding the extent and character of the gathering ground — and the run off which may be expected from it. It is, in my opinion, the best available in the neighbourhood of Bangalore. The drainage area of the Arkavati Valley up to the Nesargatta tank is 211.78 Sq miles; of this area 20.41 Sq. miles would be free gathering ground for the

12 tanks in question;
the drainage of the
remaining area is
intercepted by 171 tanks,
large and small, whose
total capacity is only
$\frac{6}{10}$ ths of the run off of
an year of average
rainfall. Assuming
the run off to be only
12 million cub ft.
per square mile in
such a year, Colonel
Campbell calculates
(see para 28) that all
the 12 tanks proposed
to be taken up will
readily

readily fill and the
terminal tank will
discharge over its
waste-weir between
400 and 500 millions
of cubic feet. He also
calculates that in a
very bad year with
only 17 inches rainfall
the tanks in question
will receive only 95·79
millions cubic feet, a
little more than a
tenth of their total
storage capacity. The
Ankarabi Valley which
drains

drains the South-
Western slopes of the
Nandidroog range of
hills and the highlands
North and North-West
of Doddballapur may
safely be expected to
yield, even in bad
years, a much better
supply than what the
above calculation
assumes. But, for
our present purpose,
it is sufficient if the
tank fills in an
ordinary year, for the
project

project is to
the supply of such a
year and make it
available for use
in a succession of
bad years.

Storage Capacity - 4 The total storage
capacity of the 12 reser-
-voirs comprised in the
scheme will be 897
millions cubic feet.
This, in my opinion,
is sufficient to afford
an un failing supply
to the present popu-
lation of Bang...
besides leaving a fair
margin

margin for the increased population of the next 10 or 20 years. The scheme also possesses a great special advantage in that it admits of large and easy additions to the storage capacity now proposed, whenever found necessary either by taking up more lands higher up in the Valley or by a slight further raising of the waste weir of the Nesar gulla bank.

Sufficiency of the proposed storage.—

5. Colonel Campbell in para 32 of his re-port, assuming the most unfavorable con-dition of rain fall known in any one year, to happen in two successive years shows that the propose storage, after allow-ing for evaporation and percolation would last for about 6 months beyond two such years. This conclusively proves the proposed storage

to

to be practically un-
-failing, for a third-
year of drought is one
of which we have no
experience whatever-
and may safely be left
out of calculation.
The two worst years on
record are

1875 with 22 inches
and 1876 with 17 inches
followed by 1877 with
39 inches.

If we again had the
misfortune to have
two years like 1875
and 1876, the storage
would cash through
those

those two years and
leave a balance
sufficient to last till
the plentiful rainfall
of the next or third year.
6. To judge fairly
of the sufficiency of the
proposed storage, it
is necessary to bear
in mind the except-
-ionally favorable
situation of the ter-
-minal storage reser-
-voir. At the end of
every year of ordinary
rainfall the 12 tanks
proposed to be taken

up

up will all be full,
and for several months
afterwards Hesar-
-gatta will discharge
over its waste weir,
for the leakage from
the upper tanks im-
-pounding 1319 mil-
-lions of cubic feet
and the tail water
of the cultivation
under them would
serve to send a con-
siderable stream
into it for several
months after the
monsoon completely
ceases

ceases. When its Waste
Weir ceases to discharge
this stream will then
flow into it to make
good its daily loss from
evaporation, percol-
-lation and supply
to Bangalore. When
this stream becomes
insufficient to keep
the tank at the Waste
Weir level, the eleven
other tanks would be
drawn upon (first
the nine minor tanks
and afterwards Kakol
and

and Byaba) to —
maintain this level.
In this way we may
expect to have Kesar-
gatta full till about
the end of March fol-
lowing a year of
ordinary rainfall.
If the next year be
the worst on record
with only 17 inches
rain, the run off
from the dry catch-
ment area would
give the small quanti-
ty of 95·79 millions
cubic

cubic feet assumed
by Colonel Campbell,
but as the actual
water spread would
be large, any small
showers falling upon
it would make a very
considerable addition
to the quantity stored.
Calculating in this
way and making
due allowance for
loss by evaporation,
percolation and
supply and for add-
-dition by rainfall
and leakage, I am
re-

be shown that the
Storage capacity -
proposed would be
sufficient for the sup-
ply of three successive
bad years follow-
-ing an average year.
But it is useless to
speculate about -
three successive years
with the known mini-
mum rainfall, for,
the worst period of
which we have any
knowledge is, as al-
ready stated, one of
2 years with 22 -
inches

inches and 17 inches respectively, and this was followed by a year with 39 inches

Quality of Water. 7. The Chemical Examiner's report shews the water as now obtained from the Valley to be fairly free from impurities. With a system of strict conservancy in the neighbourhood of Stesarghatta Kakol and Byata, and with proper filtering beds

beds at Bangalore, the quality of the water can readily be made as perfectly pure as the supply to any large town can possibly be.

Capital cost of the project.

8. Adopting the figures given in para 63 of Colonel Campbell's report, the approximate cost of the project may conveniently be distributed as follows among the main heads of Storage, Delivery and Distribution :-

Items.	Estimate of probable cost
A. Storage	
(1) Present Value of tanks	1,20,000
(2) Compensation for lands submerged and thrown out of cultivation and for houses which have to be removed	1,00,000
(3) Enlargement of tank	1,10,000
(4) Contingencies at 5%	16,500
(5) Establishment, tools and plant at 24½% on work	27,000
(6) Unforeseen Expenses	26,500
Total (A) Storage.	4,00,000
B. Delivery.	
(1) Water tower	38,000
(2) Masonry Channel 23826 ft long	1,50,000
(3) Settling tanks	44,300
(4) Pumps and Engines	2,00,000
(5) Rising cast Iron main 8580 ft. long	1,70,000

(6) Engine house and quarters for establishment.	36,000
(7) Stand post	3,500
(8) Cast iron Delivery main, 36960 ft. long	7,20,000
(9) Filtering and Service Reservoirs	1,55,000
(10) Contingencies at 5%	75,800
(11) Establishment Tools and plant	1,31,000
(12) Unforeseen Expenses.	26,400
Total (B) Delivery	17,50,000
C: Distribution	
(1) Cast Iron Distribution main, 36,960 ft. long	8,75,000.
2) Contingencies at 5 %	43,700
3) Establishment, tools and plant at 24 ½ % on cost of Work (approximate)	22,000
(4) unforeseen contingencies	9,300.
Total (C) Distribution.	9,50,000.

Items.	Estimate of probable cost.
A. Storage ——	4,00,000
B. Delivery ——	17,50,000
C. Distribution	9,50,000
Total.	31,00,000

9. It is scarcely necessary to remark that the above estimate will have to be modified in several particulars when the regular scheme comes to be worked out in detail Taken as a whole however, and for the purpose of enabling us

us to decide on the merits of the project, the estimate of 31 lacs is sufficiently accurate.

10. There are however a few points affecting the cost of the project to which I would like to refer in this place.

(1) Whether the waste weir provided for the enlarged Hesaraghatta tank is sufficiently liberal seems to require careful consideration. It may be

be found desirable hereafter to further enlarge the capacity of this bank and the section of the bund may therefore be de-signed at once so as to admit readily of such enlargement.

(2) Because the Bana-war hill is not suf-ficiently high, Mr. Scaldwell proposes to have a stand-pipe 42 ft. high on the top of that hill. Under this arrangement

etc

the delivery main
from Banawar to
Mantap hill has been
calculated to discharge
at the rate of 617.3 Cub.
feet per minute —
during 13½ working hours
out of 24. It is de-
-sirable to investigate
whether the pumping
Station can be esta-
-blished at the foot of
Chikbettahalli hill
which is 50 ft. higher
than Banawar hill
If this is found —
feasible, we can
have

have a reservoir on
the top of Chikbettahan
which will discharge
through the delivery -
main throughout the
24 hours. The distance
to mantapi hill from
Chikbettahalli being
shorter than from the
proposed stand pipe
on the top of Banavar,
and the available -
average head being
greater, there will be
a considerable reduc-
-tion in the cost of the
delivery

delivery main, re-
-quired. On the other
hand the masonry
channel from Nesar-
-gatta to the neighbour-
-hood of Chikbetta-
-halli, if at all
feasible, will involve
difficult and costly
work; but it may
be found cheaper
in the long run to
do this work and
save as much as
possible in the cost
of the Iron main
which

which is so liable to deteriorate.

(3) Supposing that it is decided to have the pumping station at the foot of the Banawar hill as now proposed, I do not see why it is necessary to resort to a stand pipe on the top of that hill. M. Scaldwell's calculations are apparently based upon the following data:-

Floor

Floor of the Service cistern on Mantap hill ——— 3055 ft. M.S.L.

Top of Banawar hill ——— 3097 ft.
Height of Stand-pipe ——— 42 ft.
} 3139 ft. M.S.L.

Head after deducting 10 ft. for depth of Service reservior. 74 ft.

Discharge in cubic feet per minute required to give a days supply of 500,000 cubic feet in 13½ hours ——— 617.3 ft.

By dispensing with the proposed stand-pipe and substituting in its place a reservoir so placed as to obtain a total head of 44 ft., I find we can slightly reduce the diameter

of

of the delivery main and yet obtain the required discharge of 347 cubic feet per minute throughout the 24 hours. If in view of an enlarged supply of the future the diameter of the delivery main is re-tained at 2 ft. a continuous discharge can be maintained of over 500 cubic feet with a head of 44 ft. and of over 400 cub. ft. with

with a head of only

34 ft.

(4) It also remains

to be investigated

whether a cheaper

scheme cannot be

had by making the

floor of the Service

cistern at Bangalore

at M.S.L. 3025 feet

instead of M.S.L. 3055

ft. and providing a

separate high level

distribution to the

few places not com-

manded by the Service

cistern

cistern at M.S.L 3025ft.

11 In these and other ways the project may workout cheaper — than 31 lacs, but it is safer to accept this figure for the purpose of our calculation of the funds required

12 The exact way in which the funds re- -quired for capital works should be pro- -vided is an im-port- -ant question which has to be reserved for settlement after Consultation

Consultation with
the Resident.

13. But there is one
item, namely storage,
of which the cost may
be left out of account
altogether, for it is
very desirable that the
Mysore Government
should provide and
maintain at its own
expense all the neces-
-sary works under
this head, levying
from the Munici-
-palities a moderate
price or a rate, to
be

be permanently
fixed, per every 10,000
cubic feet or 10,000 -
gallons of water de -
livered at the proposed
water tower near the
Hesargatta reservoir.
Under such an ar.
-rangement the dar.
-bar will of course
be expected to main.
-tain the works in
an efficient &
but without any
liability whatever to
pay damages or
Compensation

Compensation for
an interruption to
the supply owing to
any accident to the
Works, the failure
of rains or other
unavoidable causes.
An arrangement
of this kind would be
in the main in
accordance with
the practice which
prevails elsewhere
and notably at Mad-
ras where the Red
Hills tank is the
property

property of the Govern-
-ment and the water
required for consump-
-tion in the city is
believed to be sold
to the municipality
by the Government
for a fixed price.
It would be very
favorable to the
municipalities of
Bangalore, for it
would relieve them
of the responsibility
of maintaining and
conserving, and when
required of restoring

a complex system
of storage reservoirs
subsidiary to a large
existing Irrigation
system and liable
more or less to the risk
of accidents owing to
their character and
situation. It would
also secure for the
Darbar freedom from
interference of all
kinds

14. Excluding, for the
reasons above given,
storage reservoirs,
the capital cost of

the

the remainder of the project (Delivery and Distribution) amounts to Rs. 27,00,000.

Cost of maintenance. 15. The most important question of all is what payments the municipalities would probably have to every year for the proposed water-supply. Colonel Campbell in paras 86-92 gives a rough estimate of the working expenses amounting to

to Rs 2,25,000 per ~
annum. The various
items of this estimate
(excluding for the
present Depreciation)
with my observations
upon each are as
follow. —

Items	Remarks
(1) Interest on capital at 4 % —— 1,24,000.	By the exclusion of storage works, the capital cost is re-duced to 27 la-cs Other municipali-ties have to obtain their loans at 5 or 6 %. But for our present

present purpose we may calculate at 4% on 27 lacs = 1,08,000.

Loss of Revenue 5000 } This item may be omitted as it will be included in the price of the water stored

Establishment Rs. 2,112. } This, in my opinion is too low and should be raised at least to 7,000.

Fuel and small stores, 20,000. } This may be accepted.

Repairs at 1% on 31 lacs 31,000. } Repairs to storage works fall upon the Darbar

Engines

Engines, pumps and pipes cannot require so much as 1% for annual repairs. It would be sufficient if Rs. 6,000 were allowed for this purpose.

16. The total of the items revised as above amounts to 1,41,000 to which should be added the price of water payable to the State, viz, Rs 25,000. This figure is arrived at

at on the basis of interest at 4% ~~1%~~ repairs at 1% on the assumed capital cost of 4 lacs, together with Rs. 5,000, loss of Revenue. The exact amount payable will of course depend upon the price mutually agreed upon, but it may for our present purpose be put down at Rs. 25,000.

17. The annual working charges including interest on

on capital outlay
thus amounts to —
Rs 1,66,000. This sum
represents what the
municipalities have
to pay for their im-
-mediate present
requirements

18. It is however
desirable that they
should make moder-
-ate further pay-
-ments towards
making the estates
supply a perma-
-nent institution
of the place
for the benefit of
posterity

Other payments required.

posterity. These pay-
-ments will be in the
nature of contribu.
-tions towards sinking
and depreciation -
funds.

Sinking fund to repay capital outlay.

19. By paying 1% on the capital outlay ~~of 27 lacs~~ [Rs. 27,000 per annum] towards a sinking fund, the amount at the credit of that fund, allow-
-ing 4% compound Interest will amount to 27 lacs in 41·035 years

years, or a very little more
than 41 years. This
small payment ~~as~~
~~above~~ cannot be
felt as unduly bur-
-densome by the ~
municipalities. In-
deed the proposed
arrangement, if
it can be effected
will be
to extremely favor-
-able to them, for
by paying a 5% (4%
for interest and 1%
sinking fund) they
will be enabled
~~would be able~~ to
liquidate

liquidate the entire loan, principal and interest, whereas other municipalities have and to give 5% even 6% in the shape of interest alone for the loans they get.

Depreciation Fund.

20. I have been unable to get exact information regarding the probable age of Engines, Machinary and pipes. It seems difficult to believe that pipes would require renewal in less

less than 50 years. In the Vehar Water Works the pipes laid down about the year 1850 are said to be perfectly sound to this day and are not expected to require renewal for many more years. I don't think there are any instances of pipes having had to be renewed in less than 50 years under conditions of climate and quality of water such

such as we have in this province. It is therefore useless in my opinion to provide for the depreciation of pipes, a contingency very remote and uncertain. Their renewal can become necessary only long after the extinction of the capital loan and at a time when the charge could be borne with great ease by the two municipalities.

The

The case of Engines and pumps is per-haps a little different. Supposing they would require renewal every 20 years, the payment on account of their depreciation need not be more than — Rs. 6,700 or say Rs. 7,000. per annum

21. under such cir-cumstances the annual payments required for the

Total payments, re-quired for the Water-Supply and what the Municipalities can afford to pay.

the joint Scheme

be :-

	Rs
Working Charges.	58,000
Interest	1,08,000
Sinking Fund	27,000
Depreciation	7,000
	Rs 2,00,000.

22 It has always been understood that the British Government would be willing to give a liberal contribution towards the annual cost, on account of the Troops stationed at Bangalore The probable amount of such contribution

is not as yet known.

23. It is however de-
-sirable to form a
tolerably correct idea
of the limit of the
additional Revenue
which the two Muni-
-cipalities can raise
by imposing new
taxes and revising
existing ones. I am
of opinion that any
incidence of total
municipal taxation
per head larger than
Rs. 1-12-0* including
a water tax will
press with undue

* The incidence of total municipal taxation in Madras is about Rs 1.14.0 and in Puna city about Rs. 1.12.0

undue severity upon the population. The incidence of the existing taxes properly so called is already about Re.1/- per head, and an addition of 12 annas to it would give about Rs. 1,35,000 per annum which I regard as the extreme limit of what the municipalities may be able to pay for a water-supply. The proceeds of a joint system of octroi, tolls, wheel and animal taxes may

Conveniently fund be appropriated towards the expenses of the joint scheme and the balance paid by the two municipalities in the proportion of their respective ordinary populations for the time being. But the exact method in which Rs. 1,35,000 per annum or any possibly higher amount of additional municipal Revenue can be most properly raised, would require careful consideration when the pleasure of the Government of India is known on the joint scheme above

Hesargatta as an Irrigation Project.

proposed.

24. But whatever may be the ultimate decision of the British Government as regards the joint ~~such~~ ~~a~~ scheme, I think it behoves the Darbar to take immediate steps for the enlargement of the Hesargatta tank to the extent proposed, if not for the water supply of Bangalore, at least as an ordinary Irrigation Project, under the following circumstances. A large Irrigation

anikat

anikat on the Ar-
-kavati several ~
miles below Hesar-
-gatta has been ~
under the Consider-
-ation of the Darbar
for some time past.
It will have to be
practically
abandoned if the
Hesargatta tank is
to be utilized for
the water supply of
both the City and the
Station of Bangalore.
If Hesarghatta is
not used for a joint
water supply scheme,

As

its enlargement would make a better and more remunerative irriga-tion project than the proposed anikat. I would therefore cancel the project for the latter with and at once en-large the Hesargatta tank to Reduced Level 65 as proposed for the water supply scheme. Thus enlarged it would irrigate some 4,400 acres against a present achkat of 322 acres

acres and an addi-
-tional revenue of
Rs. 20,000 per annum
may therefore be safely
be expected. In work-
-ing out the details of
the Project it is perhaps
desirable to provide
a more liberal waste
-weir of say 400 ft. and
to make the front slope
of the bund flatter, say
1 in 3 or at least 1 to 2
and its section such
as, readily to permit
of a further raising
of

of the waste weir at some future time by some 3 or 4 feet. The whole work should be of as high a standard of safety as possible. I believe the present right sluice is in excellent order and would fair-ly answer for the pro-posed Irrigation Project, if supplemented by a new sluice at left side at about 50 ft., or so.

If the bank is required for the joint water-sup-ply scheme, it would be easy permanently

to close the sluices and build the proposed ~ water-tower. If the joint scheme is given up, we can readily utilize the enlarged tank partly for Irriga-tion and partly for the water-supply of the city. Thus all considerations point to the great de-sirability of enlarging the Hesaraghatta tank as above specified and I shall feel ob-liged if the Chief ~ Engineer will kindly cause the immediate preparation of ~

- cation of the sluices shown - poned to as stage as possible permit of a decision regarding the joint scheme which if favorable would dis-pense with the nec-sity for them

of the necessary ~
estimates in detail
for the orders of Govern
ment.

Bangalore 19 Feb '93 [illegible]

Introductory 1. The ~~Co~~ proposed Scheme is described in such full detail in the reports above quoted, ~~and~~ that my remarks may with ~~therefore~~ advantage ~~will~~ be confined to the more salient points requiring careful consideration

Much credit is due to Mr Caldwell for completing his ~~investi~~ preliminary investigation of this important project in the very short at his disposal ~~for the purpose~~ and for his ~~very~~ excellent report so full of information upon all points. I am very glad also that the Scheme as a whole commends itself to an Engineer of Col. Campbell ability & experience —

DEWAN'S NOTE ON THE HESSARGHATTA SCHEME OF WATER-SUPPLY TO THE CIVIL AND MILITARY STATION AS WELL AS TO THE CITY OF BANGALORE.

[1 Report by Mr Scaldwell, Executive Engineer of Bangalore, dated 10th January 1893.

2. Preliminary report by Colonel D McNeil Campbell, Officiating Chief Engineer in Mysore, dated 26th January 1893]

1. *Supply required.*—In my note of the 31st October 1892, directing the investigation of this scheme, I laid down that ~~the project~~ should provide a supply sufficient to last for 3 years for a population of 250,000 at the rate of 2 c ft. per head per day. Colonel Campbell recommends a somewhat reduced supply namely, that for a population of 200,000 at 10 gallons a day The present combined population of the Station and the City according to the Census of 1891 is 180,000, being an increase of nearly 157 per 1,000 on the population of 1881. We may reasonably anticipate a more rapid increase of population, as the result of an established water-supply and the connection, now approaching completion, of our Railway system with the East Coast Railway. I therefore think it unwise to provide for less than a population of 250,000. ~~I think~~ It would also be a mistake to give less than 2 c. ft per head per day. It is true that the people will for some time continue to resort to existing sources of supply and that, as long as they do so, it might be sufficient to allow 10 gallons per head. But these existing sources in Bangalore are of a nature likely utterly to fail in exceptional seasons like the present, and when such failure happens, the entire supply ~~would~~ will be drawn from the proposed system. It is therefore necessary that the scheme should provide a full supply. About 2 c. ft. a day is supposed to be the minimum quantity required for the troops, and though half that quantity has in some quarters been held to be sufficient for the Indian Section of the population, yet the habits of the latter are not such as would justify the proposed difference of treatment. I would accordingly assume the supply required at 2 c. ft. per day per head for a population of 250,000, and upon this basis work out the details of the scheme to be immediately carried out.

2. *Storage Reservoirs required.*—In my note of 31st October 1892, I proposed that the waste weir of Hessarghatta, which is the terminal tank across the Arkavati river, should be raised 15 ft, and those of the two tanks above it, *viz.*, Kakol and Byata, should each be raised 6 ft. Mr. Scaldwell's report shows that the proposed enlargement of Kakol and Byata would be attended with undue risk and expense, and that it would be sufficient for the practical requirements of the scheme to include in it the nine minor tanks named by him. This proposal being accepted, we need only enlarge the capacity of Hessarghatta by raising its waste weir 15 ft., leaving Kakol, Byata and the nine minor tanks

above referred to, as they now are. Thus for purposes of storage, the scheme will comprise the 12 tanks, of which particulars are given below :—

No	Name of Tank.		Mean Sea-level of waste weir	Free Catchment Area in Acres.	Area of water-spread in Acres	Capacity of Tank in Millions c. ft.
1	Hessarghatta		2,804 17	4,405	336·53	89·556
2	Byata		2,835	4,954	157 59	22·987
3	Kakol		2,834	2,553	320·55	79 896
4	Sonnamhalli ...	Nine Minor Tanks		401	18 97	3 113
5	Chikdevarpur ...			463	16 86	2·090
6	Jumbinkere ..			990	38 44	6 263
7	Arsinkunte ...			498	14 40	1·082
8	Devarkunte ...			318	16·84	1 749
9	Shanbhoganhalli...			490	7 32	0·960
10	Budamanhalli ...			656	22·14	2·984
11	Arakere ...			315 *	3·11	0·406
12	Yettikere ...			594	66·40	8 681
	Total			16,637 * or nearly 26 Sq Miles	1.019·15	219·677
	Add water-spread and capacity due to enlargement of Hessarghatta to Mean Sea level 2,819 17 ft.				1,365·47	677 781
	Grand Total.....				2,384·62	897·458

* To this should be added 4 42 Square Miles, being ½ of the partially free catchment area of certain other tanks (*Vide* Mr Scaldwell's report para 39)

3. *Catchment area available.*—The reports give full information regarding the extent and character of the gathering ground and the run-off which may be expected from it. It is, in my opinion, the best available in the neighbourhood of Bangalore. The drainage area of the Arkavati valley up to the Hessarghatta Tank is 211·78 square miles; of this area 30·41 square miles would be free gathering ground for the 12 tanks in question; the drainage of the remaining area is intercepted by 171 tanks, large and small, whose total capacity is only six-tenths of the run-off of an year of average rain-fall. Assuming the run-off to be only 12 million c. ft. per square mile in such a year, Colonel Campbell calculates (see para 28) that all the 12 tanks proposed to be taken up will readily fill and the terminal tank will discharge over its waste weir between 400 and 500 millions of c. ft. He also calculates that in a very bad year with only 17 inches rain-fall, the tanks in question will receive only 95·79 millions c. ft., a little more than a tenth of their total storage capacity. The Arkavati valley, which drains the south-western slopes of the Nundydroog range of hills and the highlands north and north-west of Dodballapur, may safely be expected to yield, even in bad years, a much better supply than what the above calculation assumes. But, for our present purpose, it is sufficient if the tank fills in an ordinary year, for the project is to impound the supply of such a year and make it available for use in a succession of bad years.

4. *Storage capacity.*—The total storage capacity of the 12 reservoirs comprised in the scheme will be 897 millions c. ft. This, in my opinion, is sufficient to afford an unfailing supply to the present population of Bangalore, besides leaving a fair margin for the increased population of the next 10 or 20 years. The scheme also possesses a great special advantage in that it admits of large and easy additions to the storage capacity now proposed, whenever found

necessary, either by taking up more tanks higher up in the valley or by a slight further raising of the waste weir of the Hessarghatta Tank.

5. *Sufficiency of the proposed storage.*—Colonel Campbell in para 32 of his report, assuming the most unfavorable condition of rain-fall, known in any one year, to happen in two successive years, shows that the proposed storage, after allowing for evaporation and percolation, would last for about 6 months beyond two such years. This conclusively proves the proposed storage to be practically unfailing, for a third year of drought is one, of which we have no experience whatever and may safely be left out of calculation. The two worst years on record are—

1875 with 22 inches and 1876 with 17 inches followed by 1877 with 39 inches.

If we again had the misfortune to have two years like 1875 and 1876, the storage would last through those two years and leave a balance sufficient to last till the plentiful rain-fall of the next or third year.

6. To judge fairly of the sufficiency of the proposed storage, it is necessary to bear in mind the exceptionally favorable situation of the terminal storage reservoir. At the end of every year of ordinary rain-fall, the 12 tanks proposed to be taken up will all be full, and for several months afterwards Hessarghatta will discharge over its waste weir, for, the leakage from the upper tanks, impounding 1,319 millions of c. ft., and the tail water of the cultivation under them would serve to send a considerable stream into it for several months after the monsoon completely ceases. When its waste weir ceases to discharge, this stream will still flow into the tank to make good its daily loss from evaporation, percolation and supply to Bangalore. When this stream becomes insufficient to keep the tank at the waste weir level, eleven other tanks would be drawn upon (first the nine minor tanks and afterwards Kakol and Byata) to maintain this level. In this way we may expect to have Hessarghatta full till about the end of March following a year of ordinary rain-fall If the next year be the worst on record with only 17 inches rain, the run-off from the dry catchment area would be the small quantity of 95·79 millions c. ft., assumed by Colonel Campbell, but as the actual water-spread would be large, any small showers falling upon it would make a very considerable addition to the quantity stored. Calculating in this way and making due allowance for loss by evaporation, percolation and supply and for addition by rain-fall and leakage, it can be shown that the storage capacity proposed would be sufficient for the supply of three successive bad years following an average year. But it is useless to speculate about three successive years with the known minimum rain-fall, for, the worst period of which we have any knowledge is, as already stated, one of two years with 22 inches and 17 inches respectively, and this was followed by a year with 39 inches.

7. *Quality of Water.*—The Chemical Examiner's report shows the water as now obtained from the valley to be fairly free from impurities. With a system of strict conservancy in the neighbourhood of Hessarghatta, Kakol and Byata, and with proper filtering beds at Bangalore, the quality of the water can readily be made as perfectly pure as the supply to any large town can possibly be.

8. *Capital cost of the Project.*—Adopting the figures given in para 63 of Colonel Campbell's report, the approximate cost of the project may conveniently be distributed as follows among the main heads of Storage, Delivery and Distribution :—

* On 10th Feby 1895 I directed the establishment of proper gauges to measure the discharge of the Streams in the present season. The results will show what may reasonably be expected from it in a bad year following a good one.

ITEMS.	Estimate of probable cost.
(A). Storage.	Rs.
(1) Present value of tanks	1,20,000
(2) Compensation for lands submerged and thrown out of cultivation and for houses which have to be removed	1,00,000
(3) Enlargement of tank	1,10,000
(4) Contingencies at 5 per cent	16,500
(5) Establishment, tools and plant at 24½ per cent on work ...	27,000
(6) Unforeseen expenses	26,500
Total (A). Storage.....	4,00,000
(B). Delivery.	
(1) Water-tower	38,000
(2) Masonry Delivery Channel, 23.826 ft long	1.50,000
(3) Settling tanks	44,300
(4) Pumps and Engines	2,00,000
(5) Rising Cast-Iron Main, 8,580 ft. long	1,70,000
(6) Engine house and quarters for Establishment	36,000
(7) Stand-post	3,500
(8) Cast Iron Delivery Main, 36,960 ft. long	~~7,20,000~~
(9) Filtering and Service Reservoirs...	~~1,55,000~~
(10) Contingencies at 5 per cent	~~75,800~~
(11) Establishment, tools and plant	~~1,31,000~~
(12) Unforeseen expenses...	~~26,400~~
Total (B). Delivery.....	17,50,000
(C). Distribution.	
(1) Cast Iron Distribution Main, 36,960 ft. long	8,75,000
(2) Contingencies at 5 per cent	~~43,700~~
(3) Establishment, tools and plant ~~at 24½ per cent on cost of work (approximate)~~	~~22,000~~
~~(4) Unforeseen contingencies ... ...~~	~~5,300~~
Total (C). Distribution	9 50 000
~~Total~~ Abstract	
(A) Storage	4,00,000
(B) Delivery	17,50,000
(C) Distribution	9,50,000
Total	31,00,000

9. It is scarcely necessary to remark that the above estimate will have to be modified in several particulars when the regular scheme comes to be worked out in detail. Taken as a whole however, and for the purpose of enabling us to decide on the merits of the project, the estimate of 31 lakhs is sufficiently accurate.

10. There are however a few points affecting the cost of the project to which I would like to refer in this place.

(1) Whether the waste weir provided for the enlarged Hessarghatta Tank is sufficiently liberal seems to require careful consideration It may be found desirable hereafter to further enlarge the capacity of this tank and the section of the bund may therefore be designed at once so as to admit readily of such enlargement.

(2) Because the Banavar Hill is not sufficiently high, Mr. Scaldwell proposes to have a stand-pipe 42 ft. high on the top of that hill. Under this arrangement, the delivery main from Banavar to Mantap Hill has been calculated to discharge at the rate of 617 3 c. ft. per minute during 13½ working hours out of 24. It is desirable to investigate whether the pumping station can be established at the foot of Chikbettahalli Hill which is 50 ft.

higher than Banawar Hill. If this is found feasible, we can have a reservoir on the top of Chikbettahalli which will discharge through the delivery main throughout the 24 hours. The distance to Mantap Hill from Chikbettahalli being shorter than from the proposed stand-pipe on the top of Banawar, and the available average head being greater. there will be a considerable reduction in the cost of the delivery main required. On the other hand, the masonry channel from Hessarghatta to the neighbourhood of Chikbettahalli, if at all feasible, will involve difficult and costly work ; but it may be found cheaper in the long run to do this work and save as much as possible in the cost of the iron main, ~~which is so liable to deteriorate~~.

(3) Supposing that it is decided to have the pumping station at the foot of the Banawar Hill as now proposed, I do not see why it is necessary to resort to a stand-pipe on the top of that hill. Mr. Scaldwell's calculations are apparently based upon the following data .—

Floor of the Service Cistern on Mantap Hill ..	M. S. L.	3,055 ft.
Top of Banavar Hill, 3,097 ft	Do	3,139 ft.
Height of stand-pipe, 42 ft.		
Head after deducting 10 ft for depth of Service Reservoir		74 ft.
Discharge in c. ft. per minute required to give a day's supply of 500,000 c. ft. in 13½ hours		617·3 ft.

By dispensing with the proposed stand-pipe and substituting in its place a reservoir so placed as to obtain a total head of 44 ft., I find we can slightly reduce the diameter of the delivery main and yet obtain the required discharge of 347 c. ft. per minute throughout the 24 hours. If in view of an enlarged supply of the future the diameter of the delivery main is retained at 2 ft., a continuous discharge can be maintained of over 500 c. ft. with a head of 44 ft., and of over 400 c. ft. with a head of only 34 ft.

(4) It also remains to be investigated whether a cheaper scheme cannot be had by making the floor of the Service Cistern at Bangalore at M. S. L. 3,025 ft. instead of M. S. L. 3,055 ft and providing a separate high level distribution to the few places not commanded by the Service Cistern at M. S. L. 3,025 ft.

11. In these and other ways the project may work out cheaper than 31 lakhs, but it is safer to accept this figure for the purpose of our calculation of the funds required.

12. The exact way in which the funds required for capital works should be provided is an important question which has to be reserved for settlement after consultation with the Resident.

13. But there is one item, namely storage, of which the cost may be left out of account altogether, for it is very desirable that the Mysore Government should provide and maintain at its own expense all the necessary works under this head, levying from the Municipalities a moderate price at a rate, to be permanently fixed, per every 10,000 c. ft. or 10,000 gallons of water delivered at the proposed water-tower near the Hessarghatta reservoir. Under such an arrangement, the Darbar will of course be expected to maintain the works in an efficient condition, but without any liability whatever on their part to pay damages or compensation for an interrupton

to the supply owing to any accident to the works, the failure of rains or other unavoidable causes. An arrangement of this kind would be in the main in accordance with the practice which prevails elsewhere and notably at Madras where the Red Hills tank is the property of the Government and the water required for consumption in the City is believed to be sold to the Municipality by the Government for a fixed price. It would be very favorable to the Municipalities of Bangalore, for it would relieve them of the responsibility of maintaining and conserving, and when required of restoring, a complex system of storage reservoirs subsidiary to a large existing Irrigation system and liable more or less to the risk of accident owing to their character and situation. It would also secure for the Darbar freedom from interference of all kinds.

14. Excluding, for the reasons above given, storage reservoirs, the capital cost of the remainder of the project (Delivery and Distribution) amounts to Rs. 27,00,000.

15. *Cost of Maintenance.*—The most important question of all is what payments the Municipalities would probably have to make every year for the proposed water-supply. Colonel Campbell in paras 86—92 gives a rough estimate of the working expenses amounting to Rs. 2,25,000 per annum. The various items of this estimate (excluding for the present Depreciation) with my observations upon each are as follows —

	Items	Rs.		*Remark.*
(1)	Interest on capital at 4 per cent	1 24 000	..	By the exclusion of storage works, the capital cost is reduced to 27 lakhs. Other Municipalities have to obtain their loans at 5 or 6 per cent But for our present purpose we may calculate at 4 per cent on 27 lakhs=1,08,000
(2)	Loss of Revenue ...	5,000	...	This item may be omitted as it will be included in the price of the water stored
(3)	Establishment ...	2,112	...	This, in my opinion, is too low and should be raised to at least 7,000
(4)	Fuel and small Stores ..	20,000	...	This may be accepted
(5)	Repairs at 1 per cent on 21 lakhs	31,000	...	Repairs to storage works fall upon the Darbar

Engines, pumps and pipes cannot require so much as 1 per cent for annual repairs It would be sufficient if Rs 6,000 were allowed for this purpose

16. The total of the items revised as above amounts to Rs 1,41,000, to which should be added the price of water payable to the State, say, Rs 25,000. This figure is arrived at on the basis of interest at 4 per cent and repairs at 1 per cent on the assumed capital cost of 4 lakhs, together with Rs 5,000, loss of revenue The exact amount payable will of course depend upon the price mutually agreed upon, but it may for our present purpose be put down at Rs 25,000

17. The annual working charges, ~~including~~ interest on capital outlay, thus amount to Rs 1,66,000 This sum represents what the Municipalities have to pay for ~~their~~ immediate present ~~requirements~~

18. *Other payments required*—It is however desirable that they should make moderate further payments towards making the water-supply a permanent institution of the place for the benefit of posterity These payments will be in the nature of contributions towards Sinking and Depreciation funds.

19. *Sinking Fund to repay Capital Outlay.*—By paying 1 per cent on the capital outlay (Rs. 27,000 per annum) towards a sinking fund, the amount at the credit of that fund, allowing 4 per cent compound interest, will amount to 27 lakhs in 41·035 years, or a very little more than 41 years. This small payment cannot be felt as unduly burdensome by the Municipalities. Indeed the proposed arrangement, if it can be effected, will be extremely favorable to them, for, by paying a 5 per cent (4 per cent for interest and 1 per cent for sinking fund) they will be enabled to liquidate the entire loan, principal and interest, whereas other Municipalities have to give 5 per cent and even 6 per cent in the shape of interest alone for the loans they get.

20. *Depreciation Fund.*—I have been unable to get exact information regarding the probable age of engines, machinery and pipes. It seems difficult to believe that pipes would require renewal in less than 50 years. In the Vehar Water Works, the pipes laid down about the year 1850 are said to be perfectly sound to this day and are not expected to require renewal for many more years. I don't think there are any instances of pipes having had to be renewed in less than 50 years, under conditions of climate and quality of water such as we have in this Province. It is therefore useless in my opinion to provide for the depreciation of pipes, a contingency very remote and uncertain. Their renewal can become necessary only long after the extinction of the capital loan and at a time when the charge could be borne with great ease by the two Municipalities. The case of engines and pumps is perhaps a little different. Supposing they would require renewal every 20 years, the payment on account of their depreciation need not be more than Rs. 6,700 or say Rs. 7,000 per annum.

21. *Total payments required for the Water-supply and what the Municipalities can afford to pay.*—Under such circumstances, the annual payments required for the joint scheme would be—

	Rs.
Working charges	58,000
Interest	1,08,000
Sinking Fund	27,000
Depreciation	7,000
Total.....	2,00 000

22. It has always been understood that the British Government would be willing to give a liberal contribution towards the annual cost, on acount of the troops stationed at Bangalore. The probable amount of such contribution is not as yet known.

23. It is however desirable to form a tolerably correct idea of the limit of the additional revenue which the two Municipalities can raise by imposing new taxes and revising existing ones. I am of opinion that any incidence of total Municipal taxation per head larger than Rs. 1—12—0* (including a water tax) will press with undue severity upon the population. The incidence of the existing taxes, properly so called, is already about Re. 1 per head, and an addition of 12 annas to it would give about

* The incidence of total Municipal taxation in Madras is about Rs. 1—14—0 and in Poona City about Rs. 1—12—0.

Rs. 1,35,000 per annum which I regard as the extreme limit of what the two Municipalities may be able to pay for a water-supply. The proceeds of a joint system of octroi, tolls, wheel and animal taxes may perhaps first be appropriated towards the expenses of the joint scheme and the balance paid by the two Municipalities in the proportion of their respective populations for the time being. But the exact method in which the Rs. 1,35,000 per annum or any possibly higher amount of additional Municipal revenue, can be most properly raised, would require careful consideration when the pleasure of the Government of India is known on the joint scheme above proposed.

24. *The Enlargement of Hessarghatta as an Irrigation Project.*—But whatever may be the ultimate decision of the British Government as regards the joint scheme, I think it behoves the Darbar to take immediate steps for the enlargement of the Hessarghatta Tank to the extent proposed, if not for the water-supply of Bangalore, at least as an ordinary Irrigation Project, under the following circumstances. A large Irrigation anikat on the Arkavati, several miles below Hessarghatta, has been under the consideration of the Darbar for some time past. It will have to be practically abandoned if the Hessarghatta Tank is to be utilized for the water-supply of both the City and the Station of Bangalore. If Hessarghatta is not used for a joint water-supply scheme, its enlargement would make a better and more remunerative Irrigation project than the proposed anikat. I would therefore cancel the project for the latter work and at once enlarge the Hessarghatta Tank to Reduced Level 65 as proposed for the water-supply scheme. Thus enlarged, it would irrigate some 4,400 acres against a present anikat of 322 acres and an additional revenue of Rs. 20,000 per annum may therefore safely be expected. In working out the details of the project, it is perhaps desirable to provide a more liberal waste weir of say 400 ft. and to make the front slope of the bund flatter, say 1 in 3 or at least, 1 to 2 and its section such as readily to permit of a further raising of the waste weir at some future time by some 3 or 1 ft. The whole work should be of as high a standard of safety as possible. I believe the present right sluice is in excellent order and would fairly answer for the proposed Irrigation project if supplemented by a new sluice at left side at about 50′ or so. If the tank is required for the joint water-supply scheme, it would be easy to close the sluices* permanently and build the proposed water-tower. If the joint scheme is given up, we can readily utilize the enlarged tank partly for Irrigation and partly for the water-supply of the City. Thus all considerations point to the great desirability of enlarging the Hessarghatta Tank as above specified and I shall feel obliged if the Chief Engineer will kindly cause the immediate preparation of the necessary estimates in detail for the orders of Government.

* In the actual execution of the work, the sluices should be postponed to as late a stage as possible to permit of a decision regarding the joint scheme which if favourable would dispense with the necessity of them

K. SHESHADRI IYER,
Dewan.

BANGALORE,
18*th February* 1893.

PRELIMIANRY REPORT ON THE PROJECT FOR SUPPLYING THE CIVIL AND MILITARY STATION AND CITY OF BANGALORE FROM THE HESSARGHATTA RESERVOIR.

INTRODUCTORY REMARKS.

1. *The Arkavati River.*—Amongst the voluminous papers connected with the Bangalore Water-supply, the proposal to utilise the waters of the Arkavati river is several times mentioned, the idea being apparently to dam up the river and pump up the water through pipes, but no details were worked out: the proposal to take water from the Hessarghatta Tank situated on that river (Latitude 13° 9′, Longitude 77° 31¾′, see map attached to report) is also referred to but seems to have been abandoned on the score of distance and lift.

2. *Previous investigations.*—The subject of the water-supply has been investigated by several officers and their investigations show clearly that it is absolutely impossible to get a sufficient supply for even the Civil and Military Station alone by gravitation and that pumping must be resorted to.

3. *Existing large catchments.*—It is also shown clearly that to get an unfailing supply in a year of deficient rain-fall the catchment area must be of considerable extent and the only such catchments are that of the Penakini river to the east, and that of the Arkavati river to the west of Bangalore.

4. *Increasing existing catchments.*—Projects have been prepared or proposed for getting large catchment areas nearer Bangalore by means of long contour channels extending to several different water sheds and by buying up series of tanks, but none of them are by any means satisfactory and the two catchments mentioned above are the only ones from which an almost unfailing supply can be obtained; an absolutely unfailing supply is of course an impossibility as with no rain or nearly none, there would be no water, whatever scheme were adopted.

5. *Arkavati and Penakini catchments.*—As regards the two sources of supply, the Arkavati is by far the most satisfactory as it is nearer, higher and contains better water and therefore the Penakini need not be considered.

6. *Dam across Arkavati River.*—To build a dam across the Arkavati river below the Hessarghatta Tank as was proposed by Colonel Vibart, R. E., would be waste of money as the bund of that Tank already forms a dam across the river at a higher level and only wants raising slightly to answer all requirements and it has consequently been settled to use the Hessarghatta Tank as the reservoir of supply.

7. *Instructions given by the Dewan.*—The idea of investigating the Hessarghatta scheme originated with the present Dewan Sir K. Sheshadri Iyer and he wrote a memo of instructions, dated 31st October 1892, giving data on which the investigations were to be made; these were:—

1*st*. The scheme to allow for a population of 250,000 people.

2*nd*. The supply to be 2 c. ft or 12½ gallons per head per day.

3*rd*. The reservoir to contain a supply for 3 years.

8. *Remarks on the Dewan's instructions—population.*—As regards No 1 the population in 1881 was 155,857 and in 1891, 180,366. showing an increase of 24,509 or 157·2 per 1,000, so that in 1901, the population will be 208,740 and in 1911, it will be 241,437, therefore in 20 years the figures laid down by the Dewan will not be reached, and though it is advisable to allow for 10 years' increase as it is believed is done in all Water-supply Projects, it does not seem right to tax one generation for the water to be supplied to a future one. It is therefore considered that the supply should be limited to that required for a population of 200,000.

9. *Supply.*—As regards No. 2 data, the supply to be given per head per diem depends on whether the scheme is to be complete in itself or whether it is to supplement the supply received from wells and other sources; in the former case 12½ gallons is none too great but in the latter 10 gallons per head ought to suffice; and as there is no doubt that a good part of the population will still resort to wells, it is thought that only 10 gallons per head should be allowed, and it must be remembered that in most of the water-supply schemes hitherto prepared for Bangalore, the supply for the Native population of the town has been taken at only 6¼ gallons and this should be considered in comparing the cost of this with other projects. It will be well here to quote from the Memo of Colonel Hasted, Chief Engineer, Madras, on the Bangalore Water-supply, in para 6 of which he writes,—"It will be well here to consider the quantity per head per diem that should be provided. In the schemes that have been proposed, this quantity varies very considerably, the highest being 20 gallons and the lowest for drinking purposes alone about 2 gallons. The ordinary allowance in England in non-manufacturing towns is 16 to 20 gallons, but in this country where water is not required for closets or for washing clothes, it may be very much less" Major Kensington says—"In Mysore according to very carefully prepared statistics, the consumption was found to be in 1874, 1¼ gallons a head per diem at the highest estimate. Surgeon E. Nicholson who was for a long time employed as Analyst of waters in Mysore, in his report, dated 13th December 1871, on the water-supply of Bangalore, puts down 3 gallons a head per diem for every man, woman and child as very liberal. The supply provided for the troops in Captain Romilly's estimates, the latest approved by Government, was about 12 gallons per head per diem, and it is considered that a very ample supply will be provided if 2 c. ft. or 12½ gallons are allowed for the troops and 1 c. ft. or 6¼ gallons for the Native population."

10. *Storage.*—As regards the 3rd data, it is not very clear if the Dewan meant that the reservoir was to contain a three years' supply independent of rain falling during that time and including evaporation and absorption, if so, the capacity of the reservoir will have to be enormous (about 1,100 millons c. ft.) and it is considered if it be large enough to contain a 2 years' supply of 10 gallons per head for a population of 200,000 people including evaporation and absorption and assuming that all of these years will be years of the lowest known rain-fall, it will be all that is required.

11. *Mr. Scaldwell's report.*—In accordance with the Dewan's Memo, Mr. Scaldwell, Executive Engineer, Bangalore Division, was ordered on the 2nd November 1892, to prepare a preliminary report on the Hessarghatta Water-supply scheme: and this report which he has prepared with great care was submitted on the 10th January 1893.

12. *Storage allowed by Mr. Scaldwell.*—The supply allowed by Mr. Scaldwell is as laid down by the Dewan, that is, 12½ gallons per head for 250,000 persons or 500,000 c. ft. per day equal to 182·5 millions of c ft per annum; but he only allows a storage capacity in the Hessarghatta and other tanks above (to be described hereafter) of 870·22 millions c. ft, which would be about ¼ that required by the Dewan, *vide* para 10.

13 *Storage required for* 200,000 *persons at* 10 *gallons per head.*—Supposing 200,000 people were to be supplied at the rate of 10 gallons (1·6 c ft. per head per-day,) this will require 320,000 c.ft. a day or 116·8 millions c. ft. per year; and the capacity allowed by Mr. Scaldwell would be more than two years' supply without any rain-fall being added.

14 *Mr. Scaldwell's figures adopted in this report.* In this report Mr. Scaldwell's figures will be adopted, but it will be shown what the results would be if the smaller ones were taken.

BRIEF DESCRIPTION OF PROJECT

15 *Tanks included in project.*—It is proposed to buy up the 8 lowest tanks of the Hessarghatta series, these are (*vide* Topo map herewith)—

Hessarghatta.	Chik Devenpur.
Byatha.	Tumbinakere.
Kakol.	Arasinakunte.
Sonnenhalli.	Dyavarakunte.

All these will be left as at present with the exception of the first named (the terminal tank), which will have its weir raised by 15.

16. *Delivery.*—In three of these tanks, 870·22 millions of c. ft. of water will be impounded, and from the Hessarghatta Tank the supply required for the town will be drawn off and carried 23,826 ft. in a masonry channel to a settling reservoir near Banawar hill, from whence it will be pumped to a stand-pipe 42 ft. high on the top of that hill (level 3,087·64) and from this stand-pipe the water will be delivered by gravitation through a 24″ cast iron main to a service reservoir and filter on mantapam hill, from whence the distribution to the Civil and Military Station and the City will be taken off.

17. *General remarks on project.*—The Project is a simple one in an engineering point of view: the chief points to be considered and discussed before the details are worked out being—

1. Quantity and storage of water available.
2. Quality of water.
3. Cost of Project.

It has been proposed to build the service reservoir at a lower level, the water required for the higher parts of the station being pumped up separately, the average level of the Petta may be, taken at under 2,970′ and therefore a reservoir with floor at 2,980 would suffice: but there are many parts of Bangalore above this level, such as the Railway Station and the houses in the vicinity, the Residency, the Palace, the Jail, the Government Buildings, houses in the neighbourhood of St. Marks and St. Andrews Churches, and the High Ground, and a large volume of water would have to be separately pumped and this is not thought advisable owing to the cost.

To command the high parts of Bangalore mentioned, omitting only the High Ground and Railway Station, a service reservoir floor about 3,025 would be required, and it is thought better to pump the extra 30′ once for all than to have separate arrangements.

QUANTITY OF WATER AVAILABLE.

18 *Present and proposed capacity of Tanks.*—In para 6 to para 28 of his report, Mr. Scaldwell has described in detail the present condition of the 8 tanks to be taken up, so it is sufficient here to state that the total capacity of all these tanks is at present 206·736 millions of c. ft., and with the weir of Hessarghatta raised 15′ the capacity will be 884·517 millions c. ft, but the 5 tanks named last in para 15 may be omitted as they are very small and shallow, the total capacity will therefore be 870·22 or say 870 millions of c. ft., which excluding evaporation and absorption is more than the 3 years' supply of 547·5 millions of c. ft. laid down by the Dewan, and would be more than 3 years of the reduced supply recommended in para 10, evaporation and percolation being *included*.

19. *Catchment area.*—The total catchment area of the Hessarghatta Tank and the 183 tanks above it is 211 78 square miles, and the free catchment of the 8 tanks to be taken up is 22·78 square miles.

20. *Extra catchment.*—In addition to this, there is a catchment of 8·85 square miles, *vide* Statement C, attached to Mr. Scaldwell's report, that is free to the extent of $\frac{2}{3}$ of the run-off during ordinary years and $\frac{1}{2}$ during years of minimum rain fall, the capacity of the tanks in that area being so small, that even in the worst years not more than half the run-off can be impounded, therefore 4·42 square miles may be added to the 22·78, giving a total of 27·20.

21. *Additional catchment proposed.*—An additional area of 3·21 square miles may be obtained by throwing out of cultivation the four very unimportant tanks mentioned in Mr. Scaldwell's Statement D. This would bring the total free catchment to 30·41. As these tanks can be bought for very little, it is adivisable that this be done.

22. *Rain-fall.*—No reliable rain-fall registers have been kept at any stations in the Hessarghatta catchment. Mr. Scaldwell submits statements of the rain-fall for the last 3 years at Nelamangala, Dodballapur and Yelahanka, but these cannot be depended upon; therefore the figures for Bangalore must be accepted, though judging from the geographical position, it is probable that the rain-fall is greater in the Arkavati valley. and this opinion is borne out by those who have had many years' acquaintance with this valley. The average yearly rain-fall at Bangalore may be taken at 35″, the minimum at 17″ and the maximum at 56″.

23. *Run-off from catchment.*—What amount of run-off can be counted on is always a doubtful point, as it depends on the nature of the rain-fall; with a yearly total of 40″ if the rain fell in small showers at considerable intervals, the run-off might be less than with a yearly total of 20″ in which there were two or three heavy downpours. (The percentage of run-off also diminishes with the increase of catchment area.)

24. *Run-off from catchment of Sankey's Tank.*—From the records of Sankey's Tank, the average run-off is about 14 per cent of the rain-fall, while the least is apparently 9 per cent; but there appears to be some error about this last figure, or else it is due to the catchment Channels being out of order, for this small percentage was received in 1888-1890 when the rain-fall was 31·12″ and 34·37″ respectively, while in 1884 when the rain-fall was only 21·67″ the amount received into the Tank was 17 per cent.

Assumed run off from the catchment of Sankey's Tank probably incorrect.

25. It has generally been assumed that in the case of Sankey's Tank the amount of-run off from 1 square mile of catchment is, 7 millions c. ft. in a bad year, 11 millions c. ft. in an average year and 17 millions c. ft. in a good year, (Vide para 4 of Chief Engineer Colonel Hasted's note on Bangalore Water-supply, dated 14th July 1888, and Colonel Bowen's note on General Fisher's Hebbal Scheme) and these figures have been adopted by Mr. Scaldwell in calculating the run-off at Hessarghatta. But they are apparently incorrect, as they mean that in a year of 17″ of rain the run-off would be about 18 per cent, in a year of 35,″ about 14 per cent, and in a year of 56″ about 12 per cent, and this is quite contrary to what is known to be a fact, *viz.*, that as a rule the percentage of run-off is less, the less the rain-fall.

Run-off assumed in other projects and amount allowed in this one.

26. In many of the water-supply schemes that have been prepared, the run-off has been taken at 13 per cent of the rain-fall in a bad year, and this amount is calculated on both by Mr. Standish Lee and Major Grant, R. E., in the Maligal Project, and taking the nature of the Maligal catchment into account, this figure is probably not too high, but in the case of the Hessarghatta catchment, which is partly cultivated and not steep, 8 per cent is perhaps as much as should safely be allowed in a year of a minimum rain-fall of 17″: this will give a run-off of 3·15 millions c. ft. per square mile.

Run-off laid down by Major Kensington from tanks catchments generally and amount calculated on in this project.

27. The late Major Kensington, R. E., who was intimately acquainted with the tanks in the Province, has laid down that the run-off in ordinary years from a catchment similar to that of the Hessarghatta, and which he describes as follows:—

" Red or black soil, porous, cultivated, or scrub jungle, or grass, catchment flat" is 20 per cent." So it will be safe to take 15 per cent or 12½ millions, say 12 millions as the run-off from 1 square mile. Therefore, during an average year of 35″ rain-fall, the total run-off from the 30·41 square miles will be 371·72 millions c. ft. and only 95·79 millions in a year of 17″ fall. The run-off from Sankey's catchment in 92 was 11 millions c. ft. per square mile, rain-fall being 27.

Run off from Kakol Tank catchment, see Mr. Scaldwell's Table F., was also 11 millions c. ft. a square mile, with rain-fall below the average and these are both far in excess of the run off allowed in the calculations in this report.

Supply from upper tanks in an average year.

28. As the capacity of the 8 tanks included in the project is 884 millions of c. ft. *vide* para 18. it follows that in an average year, the supply will not fill them, but it will be seen from Mr. Scaldwell's Table B., the capacity of the other upper tanks in the Hessarghatta series is 5,075 units or 1,319 millions c. ft. and the catchment area being 189 square miles, the run off would be 2,315 millons of c. ft. which would fill all the tanks and leave a surplus of 2,315—1,319 or 996 millions c. ft. to supply the 8 tanks, which will therefore in an average year receive 371·72 + 996 =1,367·72 millions c. ft or 1½ times what is required.

Supply from upper tanks in a bad year.

29. In a bad year however, no surplus can be expected from the upper tanks

Evaporation and percolation.

30. The exact amount of evaporation is impossible to calculate, as it depends on area of water-spread which last depends partly on the evaporation; it may be taken to be the usual amount allowed in this Province which is 6 feet per year. This is $\frac{1}{60}$" per day. (during the dry month the evaporation will be more, during the monsoons less). The bund of the tank being in good order, the percolation may be assumed to $\frac{1}{7}$th of the capacity of the reservoir. (It is doubtful however if any deduction should be made for percolation as no allowance has been made for rain-fall on water-spread of reservoirs, all of which is effective taking half area of water-spread 17' rain represents 67 millions c. ft.)

Evaporation, &c., and upper tanks.

31. No allowance is made for evaporation and percolation in the other tanks as water will be drawn off from them as soon as it falls below level of weir in the Hessarghatta, and though there will of course be a certain amount of evaporation and percolation, while the water is being drawn off, this will be more than compensated for, by the tail water of cultivation and leakage from tanks above.

Detailed calculations taking 3 consecutive years of minimum rain-fall.

32. Assuming that the tanks are full after north-east monsoon, say on 1st January 1896, and taking the worst view of this case, that is, that there are 3 years following of 17" rain only and that water is drawn off for 250,000 people at 12½ gallons per head:—

Water in tank, 1st January 1896 ..	...	884·517	Millions c. ft.
Drawn off at 500,000 c. ft. per day ..		182·500	Do.
Evaporation on half area taken contour 53 & 65		305·483	
Percolation ⅐th capacity taken do ..	...	64·473	
		25456	
Balance remaining	...	332·061	
Add received during the year at 8 per cent of rain fall of 17		95·790	
Total in reservoir on 1st January 1897 ...	...	437·851	
Drawn off as above	...	182·500	
Evaporation on half area taken contours 59 and 50	..	202·566	
Percolation ⅐th of do ..	..	34·446	
		419·512	
Balance	...	18·339	
Add received during the year 8 per cent of 17"	..	95·79	
Water in tank on 1st January 1898 ...	.	114·19	

And this would be barely a 6 months' supply

From this it will be seen that taking the worst possible view of the case the water will last 2½ years, but if the reduced supply of 116·8 millions c. ft. in the year were taken, the water would last just over 3 years, the balance on 1st January 1898 being 245·529 millions c. ft.

33. *Detailed calculation taking the 3 worst years on record.*—Now taking a rather better case, that is, with rain-fall of the 3 worst years recorded, *viz*:—

1875	... ...	22″
1876	... ...	17″
1877	... ...	39″

the percentage of run off in the first year may be taken as 10 or 160·86 millions c. ft. on 30·41 square miles.

Water in tank, 1st January 1896	884 517	Millions c ft.
Drawn off	182·5	
Evaporation	305 483	
Percolation	64·473	
Total.....	552 456	
Balance	332·061	
Received during the year	160 860	
Water in tank, 1st January 1897	492 921	
Say	493	
Water in reservoir, 1st January 189 ...	493	
Drawn off	182 510	
Evaporation	202·566	
Percolation	31·446	
Total.....419·512		
Balance say	63 488	Millions c. ft
Add received during the year 8 per cent of 17 ...	95·79	
Water in tank, 1st January 1898	159·278	

This supply would last about six months or till end of May

34. *Result arrived at.*—From these calculations it will be seen that for the large supply required by the Dewan the project as worked out in Mr. Scaldwell's report will not give a supply for 3 years taking the 3 worst years on record as a basis, but that with the reduced supply recommended in paras 8 and 9, the catchment and storage are sufficient to ensure a supply for over 3 years, even supposing that these were years with a minimum rain-fall of 17″.

35. *Ways in which supply can be increased.*—If it is considered that the supply as shown by the foregoing calculations is not sufficient, it can be increased in two ways.—

1st. By increasing catchment area.

2nd. By increasing capacity of reservoirs.

36. *Increasing catchment area.*—As it has been shown that in ordinary years the amount available for storage will be 1367·72 millions c. ft. which is more than ample, it does seem useless to increase the catchment area without increasing storage. In bad years increasing the catchment will have little effect.

37. *Increasing storage.* To increase the capacity of the Hessarghatta Tank, that is to raise the weirs more than 15 would not if is thought be safe; so the only alternative is to increase the capacities of the Byata and Kakol Tanks, so that they with the Hessarghatta will store a 3 years' supply or about 1,200 millions c ft. It was proposed by the Dewan to raise the weirs of the first two tanks by 6 but this would only give a total storage of 818·145 and to give a 3 years' supply it is probable they would have to be raised 7.

38. *Objections to increasing capacities of Byata and Kakol Tanks.*—The objections to raising the weirs of these tanks by even 6′ are given in Mr. Scaldwell's report, paras 16, 20 21 and 30 and from what he says it will be seen that it will be dangerous and expensive to increase the capacity of the tanks. Another objection is the great amount of loss owing to evaporation, &c., from 3 impounding reservoirs: with the Byata and Kakol Tanks left as they are, all the water stored in them will be run into the Hessarghatta reservoir in about 3 months, consequently the loss from evaporation will be trifling but with the capacity of these tanks increased to about 500 millions c ft., it will be over 1 year before they empty themselves with the Hessarghatta Tank and the evaporation in that time will be enormous.

39. *Reduced supply recommended.*—There can be no doubt that the storage and catchment counted on in Mr. Scaldwell's report is ample to give an unfailing supply of 10 gallons per head to a population of 200,000 persons, and it cannot be too strongly urged that the project be worked out with this supply as the basis, more especially as this will cause a considerable saving on several parts of the project. At the end of 10 years when the population has increased to 208,000, it will be time enough to think of increasing the storage, but to do so now appears to be a waste of money. One great advantage of this Hessarghatta scheme is that the total catchment being 211·78 square miles, it is capable of being extended to almost any extent by buying up tanks and increasing storage.

QUALITY OF SUPPLY.

40. *Villages on catchment.*—The catchment consists of red soil partly cultivated with dry crops; there are 8 small villages draining into the Hessarghatta Tank, their total population being about 700, the catchment area being about 7 square miles; this represents 100 per square mile, the houses or rather huts in these villages are exceedingly poor and it is thought that if a small amount of compensation per hut were paid and land given outside the catchment, there would be no difficulty in getting the people to settle elsewhere, at the same time it is believed that the amount of impurity received into the tank on account of the presence of these few people in the vicinity will be infinitesimal and it must also be remembered that after leaving the tank the water will be allowed to settle at two places and also filtered.

41. *Cultivation on catchment.*—As regards the cultivation, it is believed that very little if any manure is used, and if it is thought that there are objections on sanitary grounds to crops growing in the catchment, the project must be abandoned as the cost of buying up 30·41 square miles would be prohibitive It is quite hopeless to expect to get a catchment near Bangalore free from cultivation and habitations and it is not clear why such a condition of things is necessary; if it is necessary all that can be said is that it would be almost an impossibility to carry out a Water-supply Scheme for any large town in this or any other country. Mr. Scaldwell in para 49 of his report has given a quotation from Fanning's treatise on water-supply which is much to the point.

42. *Villages of Byata and Kakol.*—In addition to the villages named, there are two, *viz.*, Byata and Kakol draining directly into the tanks of the same name; the former consists of 150 houses and 522 inhabitants and the latter 107 houses and 331 inhabitants; these villages are too important to be removed but as the Byata and Kakol Tanks will act as settling reservoirs, it is thought the presence of these villages will not be objectionable.

43. *Analysis of Water.*—Specimens of the water taken from Hessarghatta, Byata and Kakol Tanks were sent to the Chemical Examiner and the result of his analysis is as follows:—

Quality	Byata Tank	Kakol Tank.	Hessarghatta Tank
Color	Faint cloud ..	White	Slightly cloudy.
Smell	None	Slightly earthy ..	None.
Taste	None .. .	None	None
Reaction	Neutral	Neutral	Neutral
Lime	Present	Present	Present
Chlorine	A trace	A trace	Trace.
Sulphuric acid ...	None	None	None
Nitric acid	None	None	None
Ammonia	None	None	Trace.
Sulphuric Hyd ...	None	None ..	None.
Magnesia	A Trace . .	Trace	...
Total Hardness	25 5 grs of $Ca\,C_3^{o}$ per gallon	15 40 grs. of $Ca\,C_3^{o}$ per gallon ...	19 grs of carbonate of lime per gallon.
Permanent	18 5 Ca Cl. Mg. magnesia salts	13 30 Ca Cl and magnesia salts . ..	13 6 Chloride of Calcium mainly.
Removeable	7·0 .	2·10	5 4
Organic Matter Chlorine .	Represented as ..	.	...

Two specimens from each tank were examined, one taken from the tank itself and one from the tank cistern, and the Chemical Examiner says the two specimens are almost precisely the same in each case, except that the latter is a little less hard. The following are his remarks on the water :—

Hessarghatta Tank.—" From the analysis I consider the water to be a good potable one; it might be a trifle less hard, but the total hardness is nothing like sufficient to render it unfit in any way for drinking purposes, it being just a trifle harder than the water in the Kukarhalli Reservoir at Mysore."

Byata Tank.—" The water from the tank may be said to be a good potable one and quite fit for use."

Kakol Tank.—" This water is by far the best of the three samples."

In conclusion he writes " In the event of these tanks being used as water scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably purer than it is at present."

It will be seen from this that the water of all these tanks is good and quite fit for use and that strange to say the water from the Kakol Tank close to which there is a village, is the best of the three.

The analysis is borne out by the result of inquiries which showed that the people in the villages using the water were healthy.

Of course it will be necessary to conserve the tanks to the extent of preventing people bathing or washing their clothes or cattle in them.

ENGINEERING DETAILS AND COST.

44. *Present Condition of Storage Tanks.*—The present condition of the tanks has been described in detail by Mr. Scaldwell in para 10 to 26. It is therefore only necessary to say that the Byata and Kakol Tanks are in good order and require no additions or improvements and the bund and revetment of the Hessarghatta Tank are very strong, the former being from 20 to 57′ wide at top.

45. *Hessarghatta Reservoir.*—The bund of this will be raised 15′, the revetment being dismantled and earth thrown in front and a puddle wall built throughout its length : the top width of the bund will be 15′, front slope 1½ to 1, and rear slope 2 to 1, the revetment will be strongly rebuilt on 1 ft. thick of gravel backing. F. S. L. or crest of weir being 2,819·17, top of revetment will be 2,825·17 and top of bund 2,829·17, that is, 6 and 10 ft. respectively above F. S. L.

46. *New Escape.*—A bund will be thrown across the channel leading to the present escape which is old and leaky and a new escape 300′ long will be built on the left flank. The old weir will be repaired as the surplus from the new weir will have to pass over it into the Arkavati River. The cost of these works as given by Mr. Scaldwell is—

	Rs.
Raising bund	66,069
New weir	33,543
Repairing old weir	2,020
Total Rs.....	1,01,632

this estimate is believed to be very correct, but to allow for contingencies it may be taken to be as Rs 1,10,000.

47 *Water tower.* —The position of this is shown on the plan, the design has been worked out in detail but may require some modification, but the cost Rs. 37,760 or say 38,000 may be accepted as correct : the total cost of head works will therefore be Rs. 1,48,000.

48 *Delivery Channel.*—There was considerable difficulty in settling the line for this channel and Mr Scaldwell gives a detailed description of what was finally decided upon, but it is possible that a cheaper line may still be found.

The channel is very expensive costing Rs. 1,49,790, say 1,50,000 for a length of 23,826 feet or over Rs. 6 per running foot, and it may be found that a saving can be effected, but the full amount will be entered in the estimate. The channel will have a fall of $\frac{1}{5,000}$ and will deliver 5·787 cubic feet a second running 2′ deep.

49. *Settling Tanks.*—At the end of the delivery channel, there will be 2 Settling Tanks, each holding a day's supply, from which the water will be pumped; the cost of these two tanks will be Rs. 44,286, say Rs 44,300.

50. *Pumps and Engines.*—These will be fitted up above the Settling Tank just mentioned. The pump will have to lift 5,063·6 gallons or 822·17 cubic feet a minute, 374 feet high through 1¼ mile of 24″ internal diameter rising main; calculations for the lift are given in para 59 of Mr. Scaldwell's report, these calculations being based on the fact that it is necessary to have the floor of service reservoir at 3,055 to command all parts of the station. He has allowed pumping 13½ hours a day with an additional 7 hours twice a week, but it would be better if the full supply for 7 days were pumped up in 6 days of 12 hours each, that would give the quantity to be pumped up as 5,063·6, say 5,064 gallons per minute. The Agent of the Worthington Pumping Company, Calcutta, was wired to, to ascertain the cost of suitable pumping engines and a reply was received on the 24th instant, stating inability to give quotation and suggesting a reference to Messrs. Simpson and Co., London. This latter firm has been addressed, but as it will be some weeks before an answer is received, it is not thought advisible to delay this report on that account. It will be noticed from para 81 of Major Grant's report dated 25th April 1892, that that officer received information from the Worthington Pumping Company, from which he estimates that pumps and engines to raise 930 gallons per minute to a height of 424 feet through 6 miles of rising main, will cost Rs. 1,15,000. In this case 5,063 gallons have to be raised to a height of 374′ through 1·6 miles rising main and it is not thought likely that the cost can exceed the 2 lakhs entered in the estimate.

51. *Rising Main.*—This will be laid in a straight line from the pumps to a stand-pipe on the top of Banawar Hill: it will be 8.580 feet in length, 24″ internal diameter and 1″ thick, and the cost will be Rs. 1,57,588, say Rs. 1,60,000. Add Rs 9,000 for laying and Rs 1,000 for masonry pillars. Total cost will be Rs. 1,70,000.

52. *Engine House, &c.*—The design for the Engine House and Quarters for establishment have to be worked out in detail; the approximate cost of the former will be Rs. 20,000 and of the latter 16,000.

53. *Stand-pipe.*—The level of the top of Banawar Hill +3,097 64 not being sufficiently high to give the required head over the service reservior on Mantapam Hill, floor of which will be +3,055, it is necessary to erect a stand-pipe 42 feet high; this will be combined with a signal station. The cost of this will be Rs. 3,505, say Rs. 3,500. (If the water has to be delivered in 72 hours, the height of stand-pipe 42′ as allowed by Mr. Scaldwell will not be sufficient, and a height of 70′ will be required. the cost will then probably be about Rs 5,000 and the lift will be 385.)

54. *Delivery Main.*—This will start from the stand-pipe at Banawar Hill and run in an almost perfectly straight line to the service reservoir on the Mantapam Hill; the total length will be 36,960 feet, internal diameter 24″ and thickness metal 1″. (See Mr. Scaldwell's detailed calculations, para 66.) It is usual to make 24′ pipes 1″ thick, but it is thought that it would be cheaper to reduce the thickness of metal when the pressure is low and risk chance of breakage in carriage

	Rs.
The cost at Rs 7¾ per cwt. will be...	... 6,78,861
To which must be added laying at rupee 1 per foot ..	... 36,960
5 Air Valves at Rs. 200	... 1,000
6 Scour do , 150	900
4 Do do ,, 520	... 2,080
6 Reflux Valves at ,, 500	... 3,000
Total.....7,22,801	
Say 7,23,000	

This is a very liberal estimate and it is believed that the cost will not be more than 6½ lakhs.

55. *Filtering Reservoir.*—There will be three of these, two of which will give a day's supply at the rate of 75 gallons per square foot per day. The details have not been accurately worked out, but the cost will be approximately Rs. 34,000.

56. *Service Reservoir.*—This will contain 3 days' supply: the details have not been accurately worked out, the approximate cost will be Rs. 1,21,733, say Rs. 1,22,000.

57. *Compensation.*—In para 72 of his report, Mr. Scaldwell gives the compensation to be paid on account of land thrown out of cultivation under the Byata, Kakol and Hessarghatta Tanks as Rs. 55,000; to this must be added approximately another Rs. 20,000 for land under the remaining 5 tanks, bringing the total up to Rs. 70,000, as this is only approximate and does not include the tanks mentioned in para 21, it will be safe to take Rs. 1,00,000 as the amount to be paid for compensation.

58. *Present value of Tanks.*—This is given in statement attached to para 27 of Mr. Scaldwell's report and amounts to Rs. 1,04,795: to this has to be added the value of the 4 small tanks proposed to be thrown out of cultivation, *vide* para 21, the total value may therefore be taken as 1,20,000. This estimate was made up at the request of the Dewan, the Mysore Government will not of course have to pay for their own tanks.

59. *Distribution.*—This is taken at Rs. 3½ per head and is what has been allowed in other water-supply projects for Civil and Military Station, the total cost allowing 250,000 people will be Rs. 8,75,000. No attempt has been made to work out the detail of the cost of distribution. Rs. 3½ per head is what has been allowed in other schemes for the supply of Civil and Military Station, but as the City is more compact, it is probable the average cost will be less.

60 *Establishment, Tools and Plant.*—It will be necessary to allow 24½ per cent on all items representing work, in fact on the cost of project less value of tanks, compensation, cost of piping, stand-pipe, rising main and delivery pipe; this amounts to Rs. 1,80,000. This item has not been allowed in any of the projects hitherto prepared except Major Grant's Malligal Project. It seems absurd to suppose that such a large sum will be required for a work that should not last more than 3 years and for which no special machinery or appliances will be required.

61. *Contingencies.*—Five per cent on the total estimate is allowed on this account.

62. *Unforeseen Expenses.*—For this a sum of Rs. 58,200 has been entered on this account. Not allowed in other projects but advisable.

63. *Abstract of Estimate.*—

		Rs.
1	Head Works	1,48,000
2	Delivery Channel	150,000
3.	Settling Tanks	44.300
4.	Pumps and Engines	2,00,000
5.	Rising Main	1.70,000
6.	Engine House	20,000
7.	Quarters for Establishment	16,000
8.	Stand Pipe	3,500
9.	Delivery Main	7,23,000
10.	Filtering Reservoir	34,000
11.	Service Reservoir	1,22,000
12.	Compensation	1,00,000
13.	Value of Tanks	1 20,000
14.	Distribution	8,75,000
		27,25,800
	Contingencies at 5 per cent	1,36,000
	Establishment, Tools and Plant at 24½ per cent on all items of cost	1,80,000
	Add for unforeseen expenses	58,200
	Total.....	31,00,000
		or 31 Lakhs.

64. *General Remarks on Estimate.*—The estimate is, it is believed, a very liberal one and there is no chance of it being exceeded, on the contrary a saving can probably be effected on items 2, 5, 9 and 14.

65. *Cost per head.*—The cost 31 lakhs seems high and this represents a charge of Rs. 12·4 per head of the population to be supplied and about Re. 1 per gallon per diem, but this compares favorably with many other water-supply projects, *vide* Appendix 7 of Colonel Mullin's report on the Bangalore Water-supply, from which it can be seen that in the case of the Inchalkarangi water works the cost per head was 13·6 per head. In the Jalgaon water works Rs. 13·9 per head, in the Lahore water works 11·5 per head, and in the Secunderabad water works Rs. 4 4 per gallon. It would be interesting if the cost of other water-supply scheme such as Bombay, Poona, Kirki, &c., could be ascertained for the sake of comparison.

COST OF SCHEME WITH REDUCED SUPPLY RECOMMENDED.

66. If the schemes for supplying 200,000 people with 10 gallons a day be adopted, there will be a considerable reduction in the cost of the estimate as follows.

67. *Head Works.*—The cost of head works will then be approximately Rs. 1,40,000 owing to reduction in size of water tower.

68. *Delivery Channel.*—The delivery channel will cost about Rs. 30,000 less or Rs. 1,20,000 as it will only have to discharge 3·7 c. ft. instead of 5·7 c. ft. a second.

69. *Settling Tanks.*—The settling tanks will not cost more than Rs. 30,000 as they need only contain 2,000,000 gallons instead of 3,125,000 gallons, each.

70. *Pumps and Engines.*—The pumps will have to lift 3,240·73 gallons per minute instead of 5.063 6 and they will therefore be cheaper and the price may be taken approximately at Rs. 1,80,000.

71. *Stand-Pipe.*—The stand-pipe will cost say Rs 3.000 against Rs. 3,500. In this case the stand-pipe will have to be 60′ high and the lift will be 375′.

72. *Delivery Main.*—With the reduced supply the delivery main need only be 20′ internal diameter, for a length of 18,282′ the head may be taken as 360′, the thickness of metal will therefore be 1″, for a length of 18,678′ the head may be taken as 140′ and the thickness of metal will be $\frac{7}{10}$″

The weight per foot of 20″ pipe 1″ thick is 204 lbs. per foot, therefore the weight of 18,282′ will be 1,665 tons and at Rs. 150 per ton cost will be Rs. 2,49,750. The weight per foot of a 20″ pipe $\frac{7}{10}$″ thick is 142 lbs. per foot, therefore the weight of 18,678′ will be 1,184 tons and the cost at Rs. 150 per ton will be Rs. 1,77,600. The total cost of the piping will thus be Rs. 4,27,350, to this must be added Rs. 36,960 for laying and Rs. 6,500 for valves. making the total cost of the delivery main Rs. 4.70,810 against Rs 7,20,000.

73. *Rising Main.*—The rising main will be 20″ diameter 1″ thick and will therefore weigh 204 lbs. per foot, the length being 8,580′; the total weight will be 781·4 tons and at Rs. 150 a ton, cost of pipes will be Rs. 1,17,210 add for laying, building masonry pillars, &c., Rs 9,000; total cost Rs. 1,26,210, say 1,30,000 against Rs. 1,76,000.

74. *Filtering Reservoir.*—The filtering reservoir may be smaller and the cost taken at Rs. 25,000.

75. *Service Reservoir.*—The same amount, *viz.*, Rs. 1,22,000 will be left for Service Reservoir as it is desirable that it should hold more than a 3 days' supply.

76. *Distribution.*—Distribution at Rs. 3½ per head will be Rs 7,6 0,000.

77. *Other items.*—The other item will remain as before, the total cost of the reduced scheme will therefore be as follows:—

78. *Abstract of cost of reduced scheme.*—

		Rs.
1.	Head Works	1,40,000
2.	Delivery Channel	1,20,000
3.	Settling Tank	30,000
4.	Pumps and Engines	1,80,000
5.	Rising Main	1,30,000
6.	Engine House	20,000
7.	Quarters for Establishment	16,000
8	Stand-pipe	3,000
9	Delivery Main	4,70,000
10	Filtering Reservoir	25,000
11	Service Reservoir	1,22,000
12	Compensation	1,00,000
13	Value of Tanks	1,20,000
14	Distribution	7,60,000
		22,36,000
	Contingencies at 5 per cent	1,11,800
	Establishment and Tools and Plant	1,30,000
		24,77,800
	Unforeseen Expenses, Say	47,200
	Total.....	25,25,000
	or	25¼ Lakhs

79. *Results.*—Thus it will be seen that the present population of Bangalore being 180,000, a supply of water at the rate of 10 gallons per head per diem for 200,000 people to last through 3 years of a minimum yearly rain-fall of 17″ can be secured at a cost of 25¼ lakhs, and this being the case, it does not seem desirable to expend 31 lakhs on the larger scheme.

80. *Proportion of Cost.*—Taking 31 lakhs, the proportion to be paid by the British and Mysore Government would be respectively 17·33 lakhs and 13·77 lakhs and taking 25¼ lakhs, the proportion would be 14·03 and 11·22 lakhs.

81. *Comparision of cost with other projects.*—It will be interesting to compare the cost of this project with some others that have been prepared and the following shows the result:—

Mr. Larmini's Malligal.

Scheme cost Rs. 9,79,754.
Supply 668·75 thousand gallons.
Cost per 10 gallons Rs. 14·6.

Mr. DeWinton's Malligal.

Scheme cost Rs. 11,90,000.
Supply 668·75 thousand gallons.
Cost per 10 gallons Rs. 17·7.

Major Grant's Malligal.

Scheme cost Rs. 19,05,050.
Supply 668 75 thousand gallons.
Cost per 10 gallons Rs. 28.

Present scheme.

Cost Rs. 31,00,000.
Supply 3,125,000 gallons.
Cost per 10 gallons Rs. 9·9.

Reduced present scheme.

Cost Rs. 25,25,000.
Supply 2,000,000 gallons.
Cost per 10 gallons Rs. 12·62.

So that it will be seen that as regards cost of supply per gallon the present or Hessarghatta project is the cheapest.

82. *Remarks on other water supply projects of Bangalore.*—Numerous water-supply projects have been prepared for Bangalore and it is believed they have all been finally rejected except the Hebbal and the Malligal.

83. *Hebbal Scheme.*—As it is now proposed to have a joint scheme for the City and Civil and Military Station, Hebbal Tank as a source of supply may be put out of the question as the free catchment area is only 4¼ square miles, and the total 12½ square miles, and the supply would be quite insufficient even supposing all the tanks in the series were brought up.

84. *Madigal or Malligal Scheme.*—Major Grant has lately investigated the Malligal scheme and estimates the cost at Rs. 19,05,050.

The objections to this scheme are—

1st the catchment area though a very excellent one both as regards purity and run-off, is only 10 square miles and this would be quite insufficient to give a yearly supply of 182·500 or even the reduced supply of 116·8 million c. ft. during bad years.

2nd The supply could perhaps be increased by making long and expensive contour channels into other valleys, but even if this were done the storage would be a difficult matter as several dams would be required and it is doubtful if sites for them can be found, and moreover, these contour channels would drain very highly cultivated land and thus do away with any advantage; the Madigal scheme has over the Hessarghatta as regards purity of catchment.

All things considered, it may safely be asserted that for a joint water-supply scheme the Hessarghatta possesses advantages superior to all others.

85. *Hebbal and Madigal combined.*—It has been suggested that the Hebbal Tank might be used to supply the Civil and Military Station and Madigal valley the City; but even supposing the supply to be sufficient, the united cost would be more than that of the Hessarghatta as follows.—

	Rs.
Cost of Hebbal Scheme *Vide* General Fisher's report and Col. Bowen's note thereon	2,00,000
Value of tanks	1,50,000
Compensation	40,000
Distribution	52,000
Establishment and Tools and Plant	5,000
Contingencies	50,000
Total ..	12,97,000

This estimate is only approximate and is probably below the mark. Cost of Madigal scheme as estimated by Major Grant, R. E., Rs. 19,05,050

Total cost of the two schemes, Rs. 31,02,000 against Rs. 31 or 25½ lakhs and it must be remembered that the Hessarghatta scheme supplies 12½ and 10 gallons per head for natives, while the other schemes only allow 6½ [illegible] must also be remembered that the working expenses of two schemes will be double or [illegible] double that of one.

WORKING EXPENSES.

86. It will now be necessary to consider the working expenses first taking the larger estimate of 31 lakhs.

87. *Interest on Capital.*—Interest at 4 per cent=1,24,000.

88. *Loss of Revenue on land taken up.*—The yearly loss of revenue under the Byata, Kakol and Hessarghatta Tanks will be Rs. 3,14[illegible], it is regretted that accurate information cannot be given with regard to the other tanks as it has not been received from the revenue authorities, but as they are all small it is thought that the total loss cannot exceed Rs. 5,000.

89. *Establishment.*—1 Overseer to superintend the complete system on Rs. 60=720.

1 Reservoir Superintendent and 3 Peons at Hessarghatta to regulate the supply and watch the tanks:—

	Rs.
Superintendent, Rs. 20 per month	240
3 Peons, Rs. 18	216
2 Watchmen on Banawar Hill at Rs 6	144
2 Engine Drivers at Rs 20	480
2 Stokers at Rs 7	168
2 Coolies at Rs 6	144
Total Establishment.. ..	2,112

90. *Depreciation.*—Depreciation of machinery, 7 per cent on 2 lakhs (2,00,000) . . Rs. 14,000

Depreciation of pipes, valves, &c, including distribution pipes at 4 per cent on (14,50,000) . 58,000

Fuel and small stores 20,000

91. *Repairs.*—Repairs at 1 per cent. . . 31,000

92 *Total.*—The total working expenses will therefore be Rs. 2,54,112, say Rs 2,55,000 or about Rs. 1 per head of population taken as 250,000.

93 *Working Expenses on Reduced Scheme.*—Taking the smaller estimate of 25¼ lakhs, the working expenses work out as Rs 1,86,000 or about annas 14 8 per head for a population of 200,000

94. *General Remarks on cost of working Expenses.*—This does not appear to be by any means an exorbitant taxation to impose for a good water-supply and what it really amounts to, is that each person will receive 2,190 chatties holding 2 gallons each of pure water a year at a cost of $\frac{1}{35}$ of an anna per chatti or that is, will receive delivered almost at his door 130 chatties or about a 26 days' supply for one anna

95. *Interest on Capital.*—In case an unfavorable comparison may be made as regards the working expenses of this project as compared with those of others, it may be mentioned that it is believed that in no other case has the interest on capital been added and this is a large item

96. *Concluding Remarks.*—In conclusion, it is requested that it may be borne in mind that this is only a preliminary report submitted with the object of enabling it to be decided at an early date whether the project should be investigated in detail or not

97. *Accuracy of Estimates.* Mr Southwell has worked out the cost of the different items with great care and in considerable detail, but the figures cannot be accepted as absolutely correct, though it is believed that the total will be within a few thousand rupees of the correct amount, and that any errors, there are, will be on the right side

Bangalore,
26th January 1903

D McNEIL CAMPBELL, Lieut.-Col., *R. E.*,
Secy to the Govt of Mysore. P.W.D

REPORT ON PROJECT FOR SUPPLY OF WATER FOR BANGALORE FROM THE HESSARGHATTA TANK, REGISTERED No. 73, NELAMANGALA TALUK, BY THE EXECUTIVE ENGINEER, BANGALORE DIVISION

The Dewan of Mysore in his letter of the 31st October 1892, calling for the submission of a report on the proposed project, forwarded a memo giving the scope of the same, from which the undermentioned particulars have been taken:—

2. According to the Census of 1891, the population of the Civil and Military Station is 100,081 and that of the City, 80,285. Total 180,366.

3. When the Census was taken in 1881, the total population was 155,857—the increase in ten years being 24,509, which is at the rate of 157 2 per thousand.

4. With view of meeting the increasing requirements of the Station, provision should be made for the supply of water for a population of 250,000, at the rate of 2 c. ft. per head per day, and reservoir should be of a capacity to store a supply for three years.

5. The source of supply to be the Hessarghatta, Byata, Kakol, Arsinkunte, and Chik Devanpur Tanks, situated in the Arkavati Valley, and to insure ample storage, the Dewan proposed that the weir of Hessarghatta Tank should be raised 15 feet, and weirs of Byata and Kakol Tanks 6 feet.

6. *Locality of Supply.*—The Hessarghatta Tank is situated in Latitude 13°-9′ and Longitude 77°- 31¾′, *vide* Topographical Survey Sheet No. 42. It is the terminal tank of the Hessarghatta series, which consists of 184 tanks and three "kattes," divided into seven sub-series, particulars of which will be found under the heading "Catchment Area."

7. Byata Tank lies 2½ miles to the north of the village of Hessarghatta, and Kokal Tank is situated immediately above the Hessarghatta Tank at a distance of 3½ miles higher up the Arkavati river, across which like the Hessarghatta Tank, it is constructed.

8. Arsinkunte and Chik Devanpur Tanks are very small ones, the former being on the east, and the latter on the west of the valley.

9. In addition to the five tanks mentioned by the Dewan, there are three small tanks, Dyavara Kunte, Jumbinkere, and Sonnamhalli, the former situated on the east of the valley, and latter [illegible] on the west, all of which must necessarily be thrown out of cultivation as they drain directly into the Hessarghatta Tank.

10. *Present condition of tanks forming storage reservoir* – Hessarghatta Tank, Registered No 73, Serial No. 187, Nelamangala Taluk—Constructive details are as follows:—

Waste weir on left at R. L 50 00 or M S L 2 304 17 and 290 ft in length
Bund R. L. 60·00 and top width from 10 [illegible].
Revetment . . R. L. 56 00
Area of tank at R. L 50 00=16,28,795 square yards.
Capacity at R. L 50 00=70 684 [illegible]
Right sluice . . R L. 28 95 or M. S [illegible].
Left sluice . . R. L 43·55 or M S. L 2 797 72.

*NOTE —Cross bund on right flank, which is [illegible] 220 yards [illegible], is the [illegible] portion of bund with top width less than 20 feet.

Bund and revetment in good order.
Right sluice in good order.
Left sluice somewhat leaky.
Weir—some leaks in left flank of body wall and left wing, and apron requires extensive repair.

11. Tank is stated to have been nearly dry last year, but crops were cultivated below it as usual, at time of inspection (8th December 1892) the level of water was ·65 feet below crest of weir and during the year there was 2 feet of water passing over the weir, which discharged at depths varying from 6 inches to 2 feet for sixteen days.

12. To carry out the Dewan's proposal to raise the water level 15 feet, the construction of a new weir on the high ground on the left of the tank will be necessary; and details of work proposed to be done are given in statement relating to the cost of the project.

Byata Tank.—Registered No. 206, Serial No. 182, Dodballapur Taluk.

Constructive details are as follows:—

Waste weir on right at R. L. 52·00 and 102 feet in length M. S. L. 2,835.

Waste weir on left at R. L. 52·00 and 123 feet in length.

Bund....R. L. 61 00 and top width 12 feet.

Revetment . .R. L. 57·00.

Area of tank at R. L. 52·00=762,758 square yards.

Capacity at R. L. 52·00=22·986 million c. ft.

Sluice on left, R. L. 43·88.

Sluice on right, R. L 47·24.

14. Right weir consists of a rough stone apron, laid at a slope of 1 in 12—a pit 6 feet in depth has been scoured out below the apron, at a distance of 31 feet from it, but as there is an outcrop of rock immediately below the toe of the apron, no damage is likely to occur to the weir.

Left weir in good order, and consists of a masonry body wall, with returns and a rough stone apron 138 feet in length, laid at a slope of 1 in 10—a pit 10 feet in depth has been scoured out in kodi nala, a short distance below the apron, but as there is a reef of rock running between the apron and pit, the erosion of bed of nala does not endanger the safety of the weir.

Bund is in good order but requires turfing.

Revetment in fair order.

Sluice in good order.

15. Tank was quite dry last year—on date of inspection (9th December 1892) water was 1 ft below the crest of weir, and in June last, there was a depth of 1½ feet spillage on the weir, from the run-off from the tank's own catchment—when water is passing over the weirs of Amane Madure Tank, situated immediately above, the depth of discharge on the weir of Byata Tank is 3 feet.

16. The raising of the water level 6 feet would necessitate the execution of the following work:—

Construction of a new weir on the high ground on the right flank, for which some heavy earthwork, in the way of draught channel, would be needed; construction of a body wall in front of the left weir with slabbed overfall, which would be very costly owing to the bed of tank, where new body wall would have to be constructed, being 5 feet below crest of present weir.

Raising bund to R. L. 64·00 and revetment to R. L. 62·00.

17. *Kakol Tank.*—Registered No. 200, Serial No. 134, Dodballapur Taluk.

Constructive details are given below:—

Waste weir on left at R. L. 53·00 and 212 feet in length M. S. L. 2,834.
Bund R. L. 62·00 and 9 feet in width at top.
Revetment R. L. 62·00.
Sluice on right R. L. 43·41.
Sluice on left R. L. 43·88.
Area of tank at 53·00 (present weir level) 1,551,489 square yards.
Capacity of tank at 53·00=78·845 million c. ft.

18. Bund, revetment, and both sluices in good order. Weir on left consists of a masonry body wall and rough stone apron 92 feet in length (laid at a slope of 1 in 6) with masonry toe wall and slab binding walls—the left sluice passes through the apron, and tunnel in connection with it forms a masonry binding wall for apron—the weir is in good order, but the ground below the toe wall has been scoured out 4 feet in depth for a distance of 150 feet, and extension of apron throughout this length is necessary, and will be put in hand shortly.

19. Tank was dry last year—at time of inspection (10th December 1892) water was within 6″ of crest of weir, and on the 30th of September, 3 feet of water was passing over it—the discharge over the weir during current year varied from ½ inch to 3 feet in depth for 33 days.

20. The undermentioned work will be necessary in connection with raising the water level 6 feet.

Construction of body wall in front of the weir with slabbed overfall.

Raising bund to R. L. 67·00 and revetment to the same height.

The construction of new body wall will be very costly, as the bed of tank on right flank, where it must be constructed, is 5 ft. below the crest of present weir; but there is not, I think, any alternative, as even if a new weir was constructed on the high ground to the left of the present kodi, the apron would have to be carried down to the level of toe of present apron, and construction of such a weir would prove much more expensive than that of a body wall in front of present weir.

21. In connection with the raising of weir level of this tank, I would beg to bring to notice that from the plans showing the work executed in connection with the restoration of the tank in 1877-78, it would appear that the bund was very badly breached in places, and it is to be feared that raising the weir 6 ft. in addition to the 3 ft. which it has already been raised, will possibly prove disastrous.

22. *Somanhalli Tank.*—Registered No. 211, Serial No. 136, Dodballapur Taluk.

Constructive Details.

Weir on right at R. L. 50·00 and 50 ft. in length.
Bund at R. L. 54·50 with top width of 4½ ft.
Revetment ...R. L 54·00
Sluice ...R. L 43·50
Area of tank at ...R. L 50·00=91,843 square yards.
Capacity of tank at ...R. L 50·00=3·113 million c. ft.
Bund and revetment in good order.
Sluice leaky.

Weir consists of only a rough stone apron 12 ft. in width, which should be extended 20 ft., as kodi nala has cut back to a depth of 3½ ft., within 40 ft. of apron.

Tank quite dry at time of inspection, the water stored during the year having only sufficed for cultivation.

23. *Chik Devanpur Tank.*—Registered No. 210, Serial No. 183, Dodballapur Taluk.

Constructive Details.

Weir on right at R. L. 50·00 and 36 ft. in length.
Bund at R. L. 54·50 with top width of 4½ ft.
Revetment at R. L. 54·00.
Sluice R. L. 46·31.
Area of tank at R. L. 50·00=81,621 square yards.
Capacity at R. L. 50·00=2·090 million c. ft.
Bund in good order.
Revetment bulged somewhat in places, but in fair order.
Sluice leaky and requires repair.

Weir—consists of a few rough stones laid as an apron—a masonry body wall 36 feet in length, with returns, and rough stone apron 12 feet in width wanted.

Tank dry at time of inspection, all the water stored having been used for cultivating.

24. *Jumbinkere Tank.*—Registered No. 71, Serial No. 186, Nelamangala Taluk.

Constructive Details.

Weir on left at R. L. 50·00 and 101 feet in length.
Bund at R. L. 54·50 and top width 4½ feet.
Revetment at R. L. 53·00.
Sluice at R. L. 42·58.
Area of tank at R. L. 50·00=186,088 square yards.
Capacity at R. L. 50·00=6·263 million c. ft.
Bund, revetment and sluice in good order.

Weir—consists of masonry body and toe walls with rough stone apron 24 ft. in width—ground below the weir scoured out to a depth of 3½ ft., by a water course on left flank that enters the kodi nala just below the apron—scour will not damage weir, as there is rock and laterite immediately below the toe wall.

Tank dry at time of inspection, as water stored proved only sufficient for cultivation. From marks on gauge stone it would appear that there is frequently a discharge of 3 feet in depth on the weir.

25. *Basinkunte Tank.*—Registered No. 204, Serial No. 2, Dodballapur Taluk.

Constructive Details.

Weir on left at R. L. 50·00 and 36 feet in length.
Bund at R. L. 54·50 and 4½ feet in width at top.
Revetment—none as front slope has been made 3 to 1 and turfed.
Sluice at R. L. 46·33.
Area of tank at R. L. 50·00=69,696 square yards.
Capacity at R. L. 50·00=1·082 million c. ft.

Bund is somewhat eroded at weir level, owing to neglect of renewal of turfing.
Sluice in good order.

Weir consists of rough stone apron and masonry toe wall. Kodi channel has cut back and caused the collapse of the toe wall and displacement of the whole of the apron which is 15 ft. in width. A masonry body wall 36 ft. in length, with returns and apron 30 ft. in width, carried down to bed of nala, is needed.

Tank dry at time of inspection, the water stored having proved hardly sufficient for cultivation.

26. *Dyavarakunte Tank.*—Registered No. 205, Serial No. 1, Dodballapur Taluk.

Constructive Details.

Weir at R. L, 50·00 and 25 ft. in length.

Bund at R. L. 54·50 with top width of 4½ ft.

Revetment—none, the front slope having been made 3 to 1, and turfed.

Sluice at R. L. 46·00.

Area of tank at R. L. 50·00=81,544 square yards.

Capacity at 50·00=1·749 million c. ft.

Bund—front slope eroded at weir level owing to neglect of renewal of turfing.

Sluice in good order.

Weir is a natural one, and no work is needed to it.

Tank dry, the water stored having proved only sufficient for the cultivation, notwithstanding half of the cultivable area below the tank has been taken up for casuarina plantations.

27. The annexed statement gives the approximate value of the eight tanks, comprising the project as they now stand:—

Statement of present value of eight Tanks comprising the Hessarghatta Project.

Serial No.	R. No.	Name of Tank	Storage.				Distribution.		Silt Dams	Total.	Expenditure subsequent to 1876.	Grand Total.	Remarks.
			Earth work to bund.	Revetment.	Tank waste weir.	Total.	Tank-sluice.	Total.					
1	205	Dyavarakunte ...	1,009	391	..	1,400	..	..	...	1,400	624	2,024	
2	204	Arsinakunte ..	858	281	94	1,233	160	160	..	1,393	563	1,956	
134	200	Kakol Tank ...	11,729	4,471	2,989	19,189	727	727	61	19,977	18,082	38,059	
136	211	Sonnaiahalli Attikunte .	1,057	831	133	2,021	244	244	..	2,278	346	2,624	
182	206	Byata Tank ...	6,687	2,287	1,708	10,682	199	199	...	10,881	1,952	12,833	
183	210	Chik Devanpura Tank ...	1,107	803	...	1,910	202	202	..	2,112	237	2,349	
186	71	Jumbinkere ...	1,628	759	618	3,005	302	302	...	3,307	941	4,248	
187	73	Hessarghatta Tank ..	14,708	10,110	1,011	26,222	1,239	1,239	...	27,461	13,241	40,702	
								Total Rs		68,809		1,04,79.	

28. *Storage Reservoir Capacity.*—From the statement given below, it will be seen that the present capacity of the eight tanks included in the project is 206·736 million cubic feet, and that after raising the weir of Hessarghatta Tank 15 ft., and weirs of Byata and Kakol Tanks 6 ft., the capacity will be increased to 101·170 million c. ft. The Sonnaiah, Chik Devanpur, Jumbinkere, Arsinakunte and Dyavarakunte are very shallow tanks and their capacity, with the exception of that of Jumbinkere, should I think be omitted when considering the question of storage, as the water stored in them would be lost by evaporation and percolation by the close of the year.

Name of Tank.	Present weir level.	Area of water-spred in acres.	Capacity in m.c.ft.	Proposed height of weir.	Approximate area of water-spread in acres.	Approximate capacity in m. c. ft.	Remarks.
Hessarghatta ...	50 00	374	89·556	65·00	* 1702	*767·337	Water-spread and capacity of all the tanks at R. L. 50·00 and 53·00 have been taken from the serial plans and water-spread and capacity at R. Ls. higher than 53·00 have been computed from that data. * Contour survey at R. L. 65·00 since taken and area of water-spread and capacity found to be 1,702 acres and 767·337 m. c. ft.
Byata ...	52 00	157·59	22·986	58·00	302	85·639	
Kakol ...	53·00	320 55	79·897	59 00	44·7	179·895	
Sonnanhalli ...	50·00	18 97	3·113	50·00	1897	3·113	
Chik Devanpur ...	50 00	16·86	2·090	50·00	16·86	2·090	
Jumbinkere ..	50 00	38·11	6·263	50·00	38·44	6·265	
Arsinakunte ...	50 00	11.40	1·082	50·00	14·40	1·082	
Dyavaraku te ..	50·00	16 84	1·749	50·00	16·84	1·749	
Total.. ...		957·65	206·736	...	2,556·51	1,047·170	
Total of Hessarghatta, Byata and Kakol tanks with weirs of former raised 15 ft. and those of two latter tanks 6 ft. ...					2,451	1,032·871	
Total of Hessarghatta with weir raised 15 ft. and of Byata and Kakol with weirs at present level					2,180	870·220	

29. *Quantity of water to be stored.*—To store a supply of water for 3 years, at the rate of 500,000 c. ft. per day, a reservoir of capacity of 547·500 m. c. ft. is required, and as the Hessarghatta Tank alone, with weir raised 15 ft., will store 219·837 m. c. ft. and with Byata and Kakol Tanks at present weir level 322·720 m. c. ft. in excess of this quantity, I would submit that storage reservoir should be restricted to Hessarghatta Tank with weir raised 15 ft., and Byata and Kakol Tanks at present weir level.

30. *Grounds for recommending restriction of storage reservoir.*—1st. Unnecessary, as during ordinary years there will be a constant supply from the tail water of the numerous tanks above, which will replenish quantity used and lost by evaporation for some time, and probably keep the Tanks full up to end of January.

2nd. The raising of the weirs of Byata and Kakol Tanks 6 ft., would cause the submersion of about 88 acres of wet, and 183 acres of dry land, which at Rs. 75 * and Rs. 36 * per acre, respectively, would amount to Rs. 13,005 which sum, together with the cost of work in connection with the raising of the weir (approximately Rs. 50,000) would be more advantageously expended on payment of compensation for land thrown out of cultivation under other tanks, (which will be hereafter mentioned) with view of increasing the catchment area.

3rd. The raising of weir of Kakol Tank 6 ft. in height is considered inadvisable for reasons given in para 21 of this report.

31. *Percolation and Evaporation.*—The present bund of Hessarghatta Tank is strong and sound, and there is very little percolation. The bed of tank consists of clay, and ground on both flanks of red loamy soil, with decomposed gneiss underlying it, at a depth of 8 feet below surface ; consequently, if excavation of pits within the margin of future waterspread is prohibited, and a good puddle wall carried down 3 feet below silt level at toe of present bund, also the usual precautions are taken with the extension of bund on both flanks, it is believed the loss attributable to percolation will be very small, certainly not more than 15 per cent of quantity stored.

* From enquiries made with regard to land recently sold, these rates are believed to be fair average ones.

32. Allowing as usual 6 feet loss per annum on account of evaporation, the quantity of water available in the reservoir towards the close of the first year, supposing all the tanks comprised in the project to have been full to start with, and no run-off to have been received during the South-West Monsoon, would be 245·655 m. c. ft. as per details given in annexed statement :—

Contour.	Area in acres at contour.	Capacity in M. C. ft. at contour.	Capacity in units at contour.	Remarks
50·00 ..	374	89 817	344	Area and capacity at the several contours are based on area and capacity at 50 00 and 53·00 as actually surveyed
53·00 ..	508	148 303	568	
56 00 ...	905	256 658	983	
59·00 ...	1 171	392 428	1,503	
62·00 ...	1,436	562 402	2 154	
65·00 ...	1,702	767 337	2,939	

Percolation at 15 per cent of capacity of reservoir .. 115·098 m c. ft.

Annual consumption at 500,000 c. ft. per day .. 182·500

* Evaporation allowing 6 feet in depth per annum . 340·209

Total . 637·807

Total Capacity of Reservoir 767·337

Balance . 129·530

† Add quantity stored in the other seven tanks ... 116·125

Water available in reservoir at end of first year under conditions stated in para 32, 245·655 m. c. ft.

* Evaporation has been calculated at 6 feet in depth on the mean area between 56 00 and 65 00.

† No deduction on account of percolation and evaporation has been made from storage of other tanks, as the percolation would find its way into the Hessarghatta Tank, and the evaporation would be very little, as water would be run out of the tanks immediately the level of water in the Hessarghatta Tank fell below the weir.

33. In the above calculations no allowance has been made for the tail water from cultivation and percolation from tanks situated above the Hessarghatta Tank, (which is undoubtedly a large quantity, as notwithstanding 65 m. ft. of water (over two-thirds of capacity of tank) is used annually for cultivation, yet the tank is generally half full at the end of the season during years of ordinary rain-fall.

34. *Catchment Area—Extent.*—The total catchment area of the Hessarghatta Tank, and the 183 tanks situated above it, is 211·78 square miles ; (*vide* Statement B) of which the catchment area 22·78 square miles (see Statement A) of Hessarghatta, Byata, Kakol and the five minor tanks comprised in the project is free.

Statement A, showing catchment area, capacity, area of cultivable land, assessment, &c., of eight tanks comprising project.

Serial No.	Name of Tank	Catchment area in acres	Present capacity in units.	Cultivable area and assessment as per Revenue Survey statement						Area under cultivation and revenue realized during 1891-92.						Average revenue realized during past 10 years	Remarks.
				Wet land.	Assessment.	Garden	Assessment.	Total	Assessment.	Wet land	Revenue	Garden.	Revenue	Total	Revenue.		
187	Hessarghatta ..	[illegible],105	[illegible]	[illegible]	1,2[illegible]3—12	110 19	628 4	322·12	1,[illegible]	20[illegible]·27	[illegible]	110 19	[illegible]28—4	313·[illegible]	1,811-4	† 1,[illegible]95 11 8	† Actual amount realized was only Rs. 1,344—9—0.
182	Byata ..	4,951	8[illegible]	227 22	1[illegible]6	5 95	48	23[illegible]·17	1,[illegible]	7[illegible]	[illegible] 12	10 17	77—8	[illegible]	571	[illegible]12 4 10	Not ¼th cultivated.
134	Kakel ..	2 553	305	[illegible]51 22	2,214—8	12 9	53-8	[illegible]	2[illegible]	12[illegible]	[illegible]91—8	11·20	50—12	†1[illegible]5·3	8124	963 4 10	†Little over ⅓rd cultivated
136	Sonnainhalli ..	4[illegible]1	12	50 13	251	1[illegible]6	15	[illegible]29	2[illegible]	4[illegible]·9	[illegible]20	1[illegible]	15	46·5	235	152 0 0	
183	Chikdevanpur ..	163	8	[illegible]2 27	1[illegible]3	2 13	19	[illegible]	192	[illegible]7[illegible]	112	2 13	19	30 10	162	92 0 0	
186	Jumbinkere ..	930	21	...	...	...	..	...	..	..	...		.		..	...	
1	Devankunte ..	318	6[illegible]	25 6	112	6 21	12	31 50	121	2[illegible]	122	6 [illegible]1	12	31·30	124	60 0 0	
2	Arsinkunte ..	498	4	19·29	82	1 29	[illegible]	21 18	85	19 2[illegible]	82	1 29	3	21·18	84	47 0 0	
		14,582 or 22 78 square miles.	791 7 or 206·73[illegible] m. c ft.														

From this statement it appears that only [illegible] of the cultivable land, below the 8 tanks is occupied, the calculation of compensation payable for land thrown out of cultivation by submersion, &c, has been restricted to the actual area on which assessment is now paid. The remainder of the land is valuable as pasturage and would be gladly taken up by the raiyats at a reduced rate for cultivation of other than wet crops

Statement B, showing capacity and catchment area of all tanks in the Hessarghatta Series.

Name of sub-series	Number of tanks in sub-series	Serial Numbers of tanks in sub-series	Capacity in units	Catchment area of tanks in acres	Cultivable area below tanks	Situation of sub-series with reference to the Hessarghatta works.	Remarks.
Byata	55	1 to 2 & 135 to 187	2,374 1	46,229	4,535	North-West	
Kolatur	39	3 to 41	471	24,651	1,326	North-East	In this sub-series, the run off from the catchment of 3·52 square miles would be 269·64 m. c. ft. (1,039 units) during a year of minimum rain-fall; so that even during a bad year, more than half the catchment may be considered free
Nagankere	35	47 to 81	1,015 8	23,494	2,749	Do	
Jumbinkere	16	84 to 99	605 2	13,398	1,283	Do	
Arlamalige	25	100 to 124	1,074 4	17,775	1,975	North-West	
Kakol	10	125 to 134	225 3	6,490	530	North-East	
Minor tanks	4	42 45, 46 83	68 3	3 497	277	...	
Total . ..	184		5,867 1	135,534	12,675		
Deduct catchment and capacity, &c, of eight tanks included in project (see statement)			791 7	14,582	1,115		
Balance.....			5,075·4	120,952 or 189 sqr miles	11,560		

Allowing 7 m c ft. per sq. mile as minimum run off, the supply from 189 sq miles would be 1,296 m c. ft or 4,963 units, which would hardly fill the tanks, the capacity of which is 5,075 units.

With an average run off of 11 m c. ft per sq mile, the total supply would be 2,179 m c ft or 8,345 units, and surplus would be 3,270 units or 853·785 m. c ft.

With a maximum run-off of 17 m c ft. per sq mile, the surplus would be 7,130 units or 1,861 618 m. c ft, which is upwards of three times the capacity of the whole of the eight tanks comprising the project

35. In addition to the above free drainage area, the catchment area 8·85 sqr. miles of the 12 tanks situated in the vicinity of the Hessarghatta Tank (noted in Statement C) is really free to the extent of the $\frac{2}{3}$rds of the run-off during average years, and $\frac{1}{2}$ during years of minimum rain-fall, the tanks situated within that area being so small compared with the catchment that not more than $\frac{1}{3}$rd of the run-off during ordinary years can be impounded.

Statement C of tanks draining into Kakol and Byata tanks, the catchment area of which is practically free to the extent of $\frac{2}{3}$rds of the run-off during years of average rain-fall and $\frac{1}{2}$ during years of minimum rain-fall.

Serial No.	Register No.	Name of Tank.	Taluk.	Catchment area in acres.	Capacity of Tank in M. C ft.	Cultivable Area.	Remarks.
			North of Byata Tank				
137	209	Sheresandra ...	Dodballapur ...	899	8,113,041	79	Capacity of tank only sufficient for cultivation of 32 acres as a Vaisakha crop
181	310	Kodihalli ...	Do ...	407	5,334,763	45	Do 20 do
180	317	Kallodakere ...	Do ..	300	2,999,160	30	Do 12 do
179	318	Kalloda Ané ...	Do ...	300	1,290,249	11	Do 5 do
...	46	Iyankatte ...	Do ...	381	...	17	
178	47	Matta Gaudanakere	Do ...	281	2,683,233	22	Do 10 do
			North of Jumbukere Tank.				
184	319	Mestri Palya	Dodballapur ...	253	288,468	3	
185	70	Elchalahalli ...	Nelamangala ...	380	769,419	23	Do 3 do
			North of Somanahalli.				
135	213	Karlapura Palya	Dodballapur ...	652	3,047,031	27	Do 12 do
			North of Kakol Tank				
131	214	Nellikere ...	Dodballapur ...	402	1,613,709	8·8	Do 6 do
132	234	Chellahalli Palya	Do ...	516	3,632,904	62·8	Do 14 do
133	200	Aiyan Ané Harur	Do ...	896	3,979,393	77·2	Do 15 do
			Total.....	5,667 or 8·85 sq miles.	33,751,375 or 129·26 units.	405·8 acres.	

36. With reference to run-off from other tanks, I would here mention that the whole of the Kolatur sub-series is similar in this respect, the catchment area being 38·52 sq. miles, from which a run-off of 269·64 m. c. ft. (1,032 units) could be anticipated during a year of scanty rain-fall, while the capacity of the 39 tanks comprised in the sub-series is only 471 units—the tanks however are very much scattered and at a long distance from Hessarghatta; consequently it has been considered advisable to deal with the surplus run-off from Kolatur sub-series, in the same way as with the other sub-series.

37. A further free catchment area of 3·21 sq miles might be obtained by throwing out of cultivation the wet land below the four tanks mentioned in Statement D; and if project is carried out, I would strongly recommend this being done, as the free catchment area mentioned in paras 34 and 35 is insufficient during years of minimum rain-fall when no surplus is available from the numerous tanks above.

Statement D. Tanks which might be taken up to increase the catchment area.

Serial No.	Register No.	Taluk.	Name of tank.	Catchment area in acres.	Capacity of tank in C. ft.	Cultivable area below tank.	Remarks.
			Tanks west of Kakol.				
3	172	Dodballapur .	Shanbhoganhalli ...	490	960,120	28	
4	227	Do	Bandamaranhalli ...	656	2,893,995	72	
6	225	Do	Bandamaranhalli Orrikere ...	315	405.566	39	
7	199	Do	Yallikere ...	594	8,680,851	70	
			Total.....	2,055 or 3·21 sq. miles.	16,586,532 or 63·52 units.	169	

38. With reference to the surplus from tanks situated above the tanks comprised in the project, the statement marked B, annexed, shows pretty clearly that 853·785 m. c. ft. could be anticipated during ordinary years, while during seasons of draught, the run-off would hardly equal the capacity of the several tanks.

39. From the foregoing it will be seen that the free catchment area, providing the four tanks noted in Statement D are thrown out of action, amounts to 25 99 sq. miles, to which during years of minimum rain-fall, half the catchment area 4 11 sq. miles of the 12 tanks shown in Statement C should be added. This gives a free gathering ground of 30·4 sq. miles during the worst years which are really the only ones that need be considered with reference to the project, as during ordinary years the surplus from tanks above would be much more than sufficient to fill the whole of the tanks comprised in the project.

40. *Run-off from Catchment.*—For the Rachenhalli project, Mr. W DeWinton has allowed 13 per cent run-off during a good year, which is equivalent to 0·906 m. c. ft. per sq. mile, from a rain-fall of 36."

Major S. Grant, R. E., assumes that the yield from the Mahgal catchment would be 13 per cent for a very bad year with a rain fall of 17"—25 per cent for mean year with a rain-fall of 36," and 40 per cent for a very good year with rain fall of 56"—the run-off per sq. mile based on these assumptions would be 5 134, 20·908 and 52·039 m. c. ft.

41. The records of the Bangalore Water-supply Reservoir show that the actual run-off per sq. mile has been as follows :—Minimum 7 m. c. ft., average 11 m. c ft, and maximum, 17 m. c. ft.—during the current year, which, notwithstanding the average rain-fall, amounted to 27·03," is admitted to have been a bad one, the run-off was 11·598 m. c. ft. per sq. mile=18·3 per cent.

42. Of the catchment area of 30·4 square miles, mentioned in para 38, the 3·12 square miles forming waterspread of tanks, and 12·4 square miles comprising land thrown out of cultivation below the Byata, Kakol and five other minor tanks will yield a run-off much greater than that from the catchment area of the Bangalore Water-supply Reservoir; and considering that the remainder of the catchment area, consisting of dry cultivation, will be very impervious when the tank-filling rains fall in September, it may be accepted that the catchment area in question is similar to that of the Bangalore Water-supply Reservoir.

43 *Rain-fall*.—A statement comparing the rain-fall at Nelamangala, Dodballapur and Yelahanka, in the vicinity of the catchment of the Hessarghatta series, with that on the water-supply catchment area during the past three years is appended, but with reference to the same, I would here mention that the records of the three stations are incomplete and I consider untrustworthy.

Statement of rain-fall during 1890, 1891 *and* 1892 *on catchment area of Hessarghatta Tank and at Bangalore Water-supply Reservoir.*

Year.	Month.	Rain-fall in inches and cents.				Remarks.
		Sankey's Reservoir.	Nelamangala.	Dodballapur	Yelahanka.	
1890.	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	·76	Nil	Nil	Nil	
	April	3·57	2·21	...	2 53	
	May	4·67	3 38	×	×	
	June	1 15	×	·10	×	
	July	4·02	2 22	1·92	1·94	
	August	6·95	6·16	...	3 33	
	September	3·70	3·37	1·92	4·02	
	October	3·81	...	4·98	8·65	
	November	5·66	2·39	7·42	6 38	
	December	Nil	Nil	Nil	Nil	
	Total.....	34 29	19·73	16 34	26·85	
1891.	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	·69	Nil	Nil	Nil	
	April	·28	Nil	Nil	·70	
	May	Nil	Nil	Nil	Nil	
	June	6·94	5·96	1 67	4·76	
	July	2·45	...	×	·85	
	August	2·30	×	3 34	1·41	
	September	·68	..	·51	×	
	October	5·94	×	4 20	4 30	
	November	24	46	·25	43	
	December	·26	·30	·25	Nil	
	Total.....	19·78	6 72	10 22	12 45	
1892.	January	Nil	Nil	Nil	Nil	
	February	Nil	Nil	Nil	Nil	
	March	Nil	Nil	Nil	·18	
	April	1·39	·98	1·15	1 84	
	May	4·08	5·39	2 90	1·71	* Yield from catchment 25·898 m. c. ft.= 11,598 m. c. ft. per square mile.
	June	3·95	6·70	9·32	4·24	
	July	3·66	3·31	2 32	1·63	
	August	8·32	7·11	×	9 32	
	September	2·63	2·89	5·56	1·75	
	October	2·51	2·10	1 58	2·81	
	November	·29	·90	·83	Nil	
	December	...	...	..	...	
	Total.....	* 27 03	29·38	23 66	23·48	

In places marked × thus, the returns have not been received.

44. From my knowledge, which extends over several years, of the country forming the gathering ground of the whole of the series, I think I may safely state that the rain-fall at Hessarghatta is similar to that at Bangalore, while in the vicinity of Nundydroog it is greater—allowing this, also that the catchment area is similar to that of the Bangalore Water-supply Reservoir, it follows that the yield mentioned in para 39 may be taken as the basis for calculation of annual supply.

45. *Yield anticipated from Catchment.*— During ordinary years, the supply from the catchment area would be 3344 m. c. ft., which would not half fill the impounding tanks, but this is immaterial, as the surplus alone from tanks above in addition to this quantity would supply 303·668 m c. ft more than the tanks will store.

46. The supply during a year of minimum rain-fall of 17″ would be 212·8 m. c. ft. and in the event of this occurring during the first year the supply of the station was started the result would be that 245·655 plus 212 80 m c. ft.=458·455 m c. ft would be stored for use during the following year, and level of water in the Hessarghatta Tank would be 60·00

Vide para 32

Allowing a minimum rain-fall of 17″ during the second year, there would be 172·207 m. c. ft. stored for use at commencement of third year, as per details below:—

	M. C Ft.
Quantity in reservoir at end of first year ...	458·455
Percolation 15 per cent of quantity stored ..	68·768
Annual consumption at 500,000 c. ft. per day	182·500
Evaporation allowing 6 ft. in depth per annum from mean area $\frac{1,259 \quad 639}{2}$	= 247·780
Total...	499·048
Balance Minus ..	40·593
Add the yield for the year...	212·800
Balance available at end of second year	172·209

47. The annexed Statement marked E shows the actual surplus from the Byata and Kakol Tanks and quantity lost by discharge over weir of Hessarghatta tank during the current year.

Statement E, showing surplus from Byata and Kakol Tanks and quantity lost by discharge over weir of Hessarghatta Tank durng current year.

Month.	Date.	Kakol Tank weir 202 feet			Byata Tank weirs, 225 feet.			Hessarghatta Tank weir 290 feet.			Remarks
		Depth of Discharge.	Quantity in c ft per minute	Total for 24 hours.	Depth of Discharge.	Quantity in c. ft per minute.	Total for 24 hours.	Depth of Discharge.	Quantity in c ft per minute.	Quantity in 24 hours.	
July ...	4th	1¼	1,997 01	2,875,737·6							The whole of the sub series, with the exception of the Byata, drain into Kakol Tank.
	5th	4	8,734 4	12,577,536							
	6th	8	24,698	35,565,120							The combined catchment area is 89,305 acres and capacity of the tanks inclusive of capacity of Kakol Tank 2,493 units=650·913 m. c. ft. and adding this to the quantity 935·489 m. c. ft. discharged over weir of Kakol Tank. the run-off from the whole catchment was 1,586·402 m. c. ft. equivalent to 11·3 m. c. ft. per square mile during 1892.
	7th	6	16,048	23,109,686							
	8th	3	56,773	81,753,984							
	9th	2	3,088 8	44,179,296							
	10th	1	1,091·8	1,572,192							
August ...	16th	6	16,048·4	23,109,696							
	17th	1′	1,091·8	1,572,192							
	18th	½	386·5	556, 9224							
	19th	½	386·5	556,525 4							
	20th	7	20,220·5	29,117,606 1							
	21st	7	20,220·5	29,117,606·4							
	22nd	1	1,091·8	1,572 192							
	23rd	½	386·5	556,525 4							

June 28th 1′—2¼′=63,000×60×24= 90,720,000.
29th 1—3″ =71,525× do 102,708,000.
30th 6′ =17,032× do 24,526,800.
July 5th 4′ = 9,270× do 12,348,800.
9th 3′ = 6,030× do 8,683,200.
Total c. ft.....238,986,800.

8 days-3 feet spillage on weirs=605×60×24×290×8=2,021,184,000 c.ft.
7 days-1 ft. do 214×60×24×290×7= 625,577,400 do
1 day-½ ft. do 75×60×21×290 = 31,320,000 do
* 2,678,081,400

Details of Hessarghatta Tank not kept.

Taluk Amildar states there was a discharge of 2 feet over the weir for 8 days, 1 foot for 7 days and lastly half a foot.

* Not reliable.

	24th	½″	386·5	556,525·4						
	25th	4½′	10,415·5	14,998,406·4						
	26th	4½″	10,415·5	14,998,406·4						
	27th	3″	5,677·3	8,175,398·4						
	28th	1½′	1,997·0	2,875,737·6						
September...	25th	4′	10 415·5	14,998,406·4						
	26th	9	29,468	42,433,920						
	27th	11	39,834·8	57,362,112						
	28th	8½′	27,051·2	38 954,728						
	29th	1′	1,997	2 875,737 6						
	30th	36″	211,544	308,943,360						
October ...	1st	18′	82,892	119 304,480						
	2nd	12″	45,389 2	65,360,448						
	3rd	6″	16,018 4	23,109 696						
	4th	7′	224,296	32 298,624						
	5th	1	1,091 8	1,572,192						
	6th	1	1,091 8	1,572 192						
	7th		[illegible]	[illegible]						
Total year ...				33[illegible],189,371 c ft			238,986 800 c ft		2,678,081,400 c. ft.	

NOTE.—Velocity of approach not known.

18. *Sanitary Condition of Catchment area.*—There are eight villages, particulars of which, with regard to population, &c., are given below situated in the vicinity of the margin of Hessarghatta Tank, and draining directly into it, and in addition to these, there are the villages of Byata and Kakol draining directly into the tanks of the same name :—

West of Arkavati valley, villages draining directly into Hessarghatta Tank.

Sonnamhalli	115 houses and	415	inhabitants.
Chikdevanpura	..	..	
Basvanpur	57 ,,	246	,,
Ramsandrapallya	...		
Kodinayakanhalli	...	...	
(Jodi village)	17 ,,	100	

East of Arkavati valley villages draining directly into the tank.

Harohalli	42 houses	152	inhabitants
Dasserhalli	,,		
Gundajalli	82 ,,	234	,,
Total..	313 ,,	1,147	,,

Byata and Kakol villages consist of 150 and 107 houses and contain 522 and 331 inhabitants, so that the total population located in the vicinity of the Hessarghatta Tank is only 2,000, and I would submit that being so small, the removal of the villages is unnecessary; but better sanitary arrangements are requisite, especially in the villages of Byata, Kokal, Kodinayakanhalli and Gundahalli.

19. With regard to the necessity or otherwise of removal of villages, I would mention that in Fanning's—treatise on water-supply, it is stated as follows.—"About one-half the population of London, or one-half million persons received their domestic water-supply from the Thames in 1875."

Contours at R. L. 6500 since taken show that Ramasandra Palya and Chikdevanpur on the west of the valley and Herohalli and Gundahalli on the east will be on the margin of the tank, and these 4 villages must necessarily be removed.

"The drainage area above the pumping stations is about 3,675 square miles, and the minimum summer flow is estimated to be 350,000,000 imperial gallons daily and of this flow about 15,000,000 gallons is pumped daily by water companies. Upon the Thames water-shed above the pumping stations there resides a population of about 1,000,000 persons, including three cities of over 25,000 persons each, three cities of from 7,000 to 10,000 each, and many smaller towns and villages"

"The whole of the river and its principal tributaries are under the strictest sanitary regulations, which the Government is able to enforce, notwithstanding which a great mass of sewage is poured into the stream."

20. *Analysis of water*.—Specimens of water taken from the tank and from the sluice of Hessarghatta, Byata and Kakol tanks have been forwarded to the Chemical Examiner of Mysore, but analysis of same has not yet been received—the water in the Hessarghatta and Kakol Tanks appears to be good but that of Byata is rather discoloured and probably contains vegetable impurities which must be due to the wet cultivation below the Amani Madhurai and Sheresandra Tanks having been extended into the bed of the Byata tank—this cultivation will I think cause much greater pollution of the water, than any that can arise from the small villages, and wet cultivation should I think be certainly prohibited within 100 yards of the margin of the whole of the tanks comprised the project.

Annexed.

HESSARGHATTA TANK.

PHYSICAL EXAMINATION—*Taken from the Tank.*

Color	Slightly cloudy
Smell	None
Taste	None
Reaction	Neutral
Lime	Present
Chlorine	A trace
Sulphuric acid	None
Nitric	None
Ammonia	Trace
Sulphuratted Hydrogen	None
Hardness Total	19 grs of carbonate of lime per gal.
Permanent	13 6 chloride of calca (mainly)
Removable	5 4
Organic matter	

Water taken from Sluice Cistern.

Almost precisely the same, only the amount of hardness both total and permanent is a trifle less, but nothing to speak of.

Opinion.—From the analysis I consider the water to be a good potable one, it might be a trifle less hard, but the total hardness is nothing like sufficient to render it unfit in any way for drinking purposes, it being just a trifle harder than the water in the Kukarhalli Reservoir at Mysore

---

BYATA.

TWO SPECIMENS SENT

A. Tank water.

Color	Faint cloud
Smell	None
Taste	None
Reaction	Neutral
Lime	Present
Chlorine	A trace
Sulphuric acid	Nil
Nitric	Nil
Ammonia	Nil
Sulphuratted Hyd.	Nil
Magnesia	A trace
Total hardness	25 5 grs. of Ca Co7 per gal
Permanent	18 5 Ca C—Magnesia salts
Removable	7 0
Organic matter	represented as
Chlorine	

Water taken from the sluice.

Almost identical with the above—only it is a trifle less hard.

The water from the tank may be said to be a fair potable one and quite fit for use.

KAKOL TANK.

TWO SPECIMENS.

Water from the tank.

Color	...	..	White
Smell	...	...	Slightly earthy
Taste	...	...	None
Reaction	...	...	Neutral
Lime	...	...	Present
Chlorine	...	...	A trace
Sulphuric acid	...	...	Nil
Nitric	...	...	Nil
Ammonia	...	...	Nil
Sulphuratted Hyd.		...	Nil
Magnesia	...	...	Trace
Total hardness	...	...	15·40 grs. of Ca Coz per gal
Permanent	..	...	13·30 Ca C l Magnesia salts
Removable	...	...	2·10 Ca Coz
Organic matter			

The other sample is precisely the same. This water is by far the best of the 3 samples sent.

In the event of these tanks being used as a water scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably better than it is at present.

(Intd) P. H B.

---

51. (A) *Brief description of project.*—It is proposed to impound 883·462 m. c. ft. of water in the eight tanks mentioned in para 28, and to deliver the same at the rate of 500,000 c. ft. per day into filter and service reservoirs located on the Mantapam Hill to the north of Bangalore.—(B) At Hessarghatta Tank a water tower will be constructed with valve at M. S. L. 2,796-84, from which water will be led by means of covered masonry channel 23,826 feet in length with a fall of 1 in 5,000 to settling reservoirs located close to a pumping station situated a short distance from the Bangalore-Tumkur branch of the Southern Mahratta Railway, half a mile north-west of the village of Banawar.—(C) From the pumping station the water will be raised to a stand post 42 feet in height constucted on the top of the Banawar Hill, the M. S. L. of which is 3,097·64.—(D) From the stand-post the water will be delivered in a cast iron Main, 24″ diameter by gravitation into filtering cisterns and service reservoirs, the combined capacity of which will be equal to five days' supply.—(E) The floor of service reservoirs to be at M. S. L. 3,055, which will give a sufficient head for an economical distribution to the Cantonment and City of Bangalore, the former of which being so widely scattered a maximum head is indispensable, unless the higher portions of Bangalore are provided with a separate service, which it is quite possible might prove to be the most economical.—(F) From the storage reservoirs service mains would be taken, one in a direct line to the Bangalore District Office for the City and the other to the Cantonment Railway Station, from which branches could be taken off for supply of northern and southern portions of Civil and Military Station.

52. Prior to entering into details of cost, &c., of the several items of work, I would here remark that the project is analogous to that referred to by Colonel H. M. Vibart, R. E., in paras 2 and 3 of his letter No. 2946, dated 20th October 1887, to the Chief Engineer, Madras Public Works Department (*vide* page 247 of Memorandum of Bangalore Water-supply) with reference to which, I would state that I have recently investigated a project (details of which are given below) for the construction of a dam across the Arkavati river, at a site situated 2½ miles below the bridge on the 12th mile of Salem-Bellary road, for irrigation of 2,000 acres of land on both banks of river; regarding which, it is only necessary here to mention that construction of a dam impounding more than 154·310 millons c. ft. of water is impracticable without endangering the safety of the Southern Mahratta Railway bridge across the same river.

Mean sea level of bed of river at proposed site of dam	...	2,718·56
Do of crest of dam	...	2,74[illegible]·56
Quantity of water impounded	...	1,543 10 M c. ft
Cost of dam...	...	Rs. 40,451
Cost of raising road bridge 15 ft, ...	..	16,506
Probable amount of compensation for land submerged		8,940
Contingencies at 5 per cent		3,297
	Total	Rs.....69,254

STATEMENT OF PROBABLE COST OF PROJECT.

53. *Head works.*—Raising weir of Hessarghatta tank 15 ft. in height.

Constructive Details.

Weir on left flank at R. L. 2,819 17 and 300 feet in length.
Bund to R L. 2,829 17 with top width of 15 ft. front slope 1½ to 1 and rear slope 2 to 1.
Revetment at R. L. 2,825 17.
Cill of sluice at R. L. 2,796·84
Area (approximate) of waterspread at 2 819·17=1,702 acres.
Capacity at R. L 2,819·17=2,116½ units=767·337 m. c. ft

(*a*) *Bund.*—The right flank will be in continuation of the present cross bund, constructed during 1877. On the left flank, a cross bund will be taken off at bend in bund, at a distance of 330 yards from the present weir (See C. S. No. 5 on plan) and from thence will be continued to the High Ground, where it tails off at R. L. 2834·57.

							R
Earthwork		167,154 C. Yds. at	3 As	per yard		...	31 11
do		11,988	do	1½	do do	...	1 124
Old stone revetment		2,190	do	10	do do	...	1 63
New	do	16,356	do	1¼ Rs	do do	...	20,445
Old stone	do	1,118	do	12 As.	do do	...	899

(Stone to be taken from the abandoned portion of bund on right flank)

Removal of right sluice and refilling bund	L. S 300
Ring bunds at sluices while undergoing removal	L. S 500
Repair of left sluice to allow of cultivation of garden land from water impounded between new and old weirs	L. S. 500

Puddle trench and wall.—

	As.	Rs.	
Excavation 14,988 C. Yds. at	1½	1,405	Rs. 9,591
Puddle wall 26,196 C. Yds. at	5	8,186	

Total for Bund Rs.....66,069

(*b*). *Waste Weir.*—It is propsed to repair and retain the present weir and to construct another weir above it, in the new bund on the left flank, as per plan—the crest will be at R. L. 2,819 17 and toe at R. L 2,791·79—the weir will consist of a masonry body wall with wings, masonry binding walls 39½ feet apart in apron and toe wall, the apron being sujikat of the best quality 1 yard in depth

			Rs.	A.	P.		
Brick in chunam ...	17 802 C. Ft.	at	0	3	0	per C. Ft. .	[illegible]
Plastering with mortar .	21·05 Sqrs	at	3	0	0	per square ..	9[illegible]
Sujikat	6,014 C. Yds.	at	1	8	0	per C Yd. ..	[illegible]
Earthwork, cutting approach to weir... ...	*6,188 C. Yds.	at	0	1	0	per C. Yd.	[illegible]
Do do for apron, &c.	64,253 ,,	at	0	2	0	do ..	[illegible],032
Do do draught channel from the weir ..	1,46,300	at	0	1	0	do ...	[illegible],144
Revetment to sides of apron and of draught channel above and below weir.	1 160 C. Yds.	at	1	4	0	do ..	1 450
Stone slabs 8 at 8 annas per S Ft 4,159		...					[illegible]
						Total for new weir Rs...	[illegible]

* * to be used for bund.
* * Earth to be used for bund at rate of 4 annas per C. Yd. which will reduce the rate of earthwork for weir to one anna per C. Yd.

					Rs.
(c) *Repair of old weir*—			Rs. A. P.		
Brick in chunnam ...	3,444 C. Ft.	at	0 3 0	per C Ft. ...	646
Plastering with mortar ...	21 65 Sqr.	at	3 0 0	per Sqr. ...	65
Pointing with Portland cement	22 16 Sqr.	at	5 0 0	do ...	111
Old stone sujikat 46 C Yds.	...	at	0 10 0	per C. Yd. ...	29
Sujikat apron 350 do	...	at	1 8 0	per do ...	525
Stone slabs 8′ × 454 S. Ft.	..	at	0 8 0	per Sqr. Ft ...	227
Jelly packing to apron .	1,245 Sqr. Yds.	at	0 1 6	per Sqr. Yd. ...	117
Petty jobs ...	... Lump sum		...	...	100
Blasting ...	... do		...	...	150
Earthwork ...	... do		...	...	50
				Total for repair of work Rs.....	2,020

54. *Water Tower*:—

(A). It was first proposed to take off the delivery channel through the left flank of the new cross bund, at a short distance from the weir, and to follow the left bank of the river; but longitudinal section taken along this line shows that it is impracticable, as the ground is cut up into numerous ravines, across which it would be impossible to construct a water-tight channel except at a very heavy outlay, and moreover for upwards of half a mile, the channel would be below flood level of river (*see* Sheet No. 12).

(B). In accordance with the Chief Engineer's instructions, given on his inspection of the tank, sections were taken along the right slope of the old abondoned bund of tank (*see* Sheet 13). A delilvery channel along this line is practicable, but would prove very costly, as two breaches (one of which is a very large one) in the old bund would have to be filled in, and an aqueduct 200 feet in length would be required where the channel necessarily crosses the river.

(C). The cost of filling in breaches would amount to Rs. 2,680 and that of aqueduct to Rs. 3,275, in addition to which a sum of Rs. 191 would have to be expended on excavation—the total outlay would thus amount to Rs. 6,146 which, although very heavy, would not be prohibitive, were it not that the aqueduct would be insecure—the flooring of the delivery channel being only ·35 feet above flood level in river, which would necessitate placing the under surface of girders at least ·77 feet below that level.

(D). The above mentioned lines being practically not feasible, another line was selected, which skirts the left end of proposed cross bund and then passes along the high ground at a short distance above the first line, quite clear of all ravines (*see* Sheet No. 14).

(E). The excavation will be from 14 to 24 feet in depth, but cost of same (Rs. 2,619) is much less than the cost of filling in the breaches and construction of aqueduct on the second line, and the alternative line, shown on Sheet No. 14, is, I think, the only practicable safe one.

(F). The alignment of the delivery channel being necessarily outside of the weir, the water tower must of course be in a similar situation, and site selected is the margin of the present water-spread, at a distance of 600 feet above the new weir, and well out of line of draught to it.

(G). The water tower will be similar to that constructed at the Bangalore Water-supply Reservoir (*vide* Sheet No 17), the only exception being that valves will be placed at sluice openings, instead of wooden shutters.

(H). The tower will be octagonal 6 feet internal and 15 feet external diameter with vents at R. L. 2,796·84—2,804·28 and 2,811·72, and top at R L. 2,823·17, or 4 feet above crest of weir.

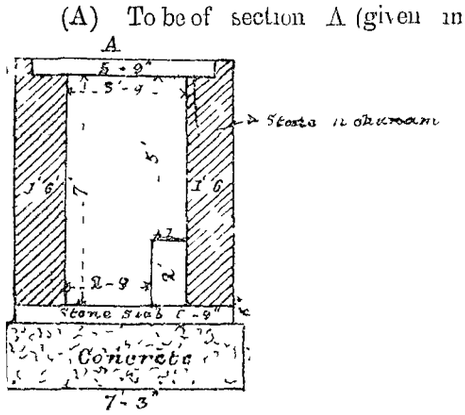
(i) A tunnel 676 feet in length will be constructed from the water tower, in which a 30′ cast iron flanged pipe laid at a slope of $\frac{1}{100}$ will be fixed, and fitted with valves in water tower and at end.

55. The approximate cost of the work is as follows :—

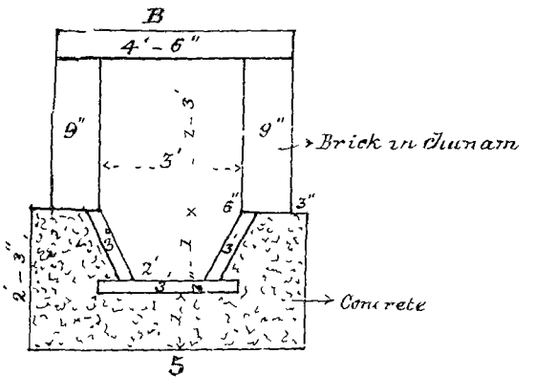
		C. Yds.		Rs.
(A)	"Earthwork"—			
	Excavation for open channel to water tower	622		
	Do for tower ...	1,648		
	For tunnel from tower ...	16 055		
	Total.....	18,325	at 2 as. 6 p. =	2 863
		C. ft.		
(B)	Concrete in Surki—			
	For foundation of tower 18' × 18' × 2' =	684		
	Do of tunnel 750 × 13 × 2 =	19 500		
	Superstructure of towers	5,660		
	Total.....	25 844	at 3 as. 3 p. =	250
(C)	Stone in Surki mortar—			
	For foundation of tower	919		
	Do of tunnel . ..	19 500		
	Superstructure of tower .. .	1 300		
	Total ..	21,719	at 3 as. 3 p. =	4 412
(D)	Cut stone work—			
	For tower... ...	788	at Re 1 =	78
	Dressed Quoins... Sq. ft.	1 278	at 4 as =	319
(E)	Brick in Surki mortar—			
	Ventilating shaft ..	1 128		
	Side walls of tunnel ..	11 210		
	Total.....	12,338	at 3 as. 3 p.	2 511
(F)	Archwork in Surki mortar—			
	For tunnel	2,600	at 6 as. =	9,375
(G)	Stone Slabs 8 dressed—			
	For floor of tower Sq. ft.	1 7		
	Do of tunnel	6 375		
	Total.....	6,532	at 12 as. =	4,899
(H)	Cast iron flanged piping 30 diameter and 1 thickness of metal—			
	50 R. ft. weighing 2·68 cwt. per feet run 1 19 cwt at Rs. 9—8—0 per cwt.		=	1,415
(I)	Carriage to site and fixing—			
	50 R. ft. at Rs 1—8—0 per R. ft.		=	75
(J)	Valves 30 double faced with gun metal (inclusive of carriage, &c.)—			
	No. 5 at Rs. 750 each			3 750
(K)	Open channel as per section in margin—			
	700 R. ft. at Rs. 3 per R. ft		=	100
	Total cost of water tower.....			27,500

56. Delivery Channel.

(A) To be of section A (given in margin) from end of tunnel of water tower up to the 54th chain, (*vide* sheet No. 11) where it falls off into low ground, with ventilating shafts and silt traps at every ten chains.



(B). From the 54th chain, the channel will be of section marked B, with acqueduct at drainage crossings as mentioned in the subjoined report, and silt traps at every ten chains—the fall throughout will be $\frac{1}{5000}$ and both sections of channel will discharge more than the required quantity (5·787 cubic feet per second) when flowing 2 feet in depth.



(C). The channel as now aligned is very crooked, and, in addition to the alteration in the first 54 chains, several other deviations will be necessary, the principal being on chains 72 to 120, from chains 162 to 178 and from 270th to 305th.

(D). From 54th chain to 83rd chain the channel passes through dry cultivation, at 83rd chain it enters gardens, and continues in these up to 108th chain; the crossing of the kodi nala of Aivardanpur Tank is at the 99th chain where floor of channel is at R. L. 2,792·34 and bank of nala (which is frequently topped) at R. L. 2,796·89.

(E). This portion of channel (from 72nd to 120th chain) must be altered and longitudinal section of deviation is given in Sheet No. 15 from which it would be seen that the length of the channel can be decreased by 2,446 feet; the channel will be raised above the level of the ground for a distance of 688 running feet, and some arrangements will have to be made for irrigation of land lower down the valley, as the present earthen dam across kodi channel, by means of which irrigation is now carried on must be removed, the cost of such work will, however, be more than counter-balanced by saving in length of channel.

(F). From 120th chain the channel runs close to Aivardanpur irrigation channel up to 126th chain, from whence it turns to the left and runs through dry cultivation up to 162nd chain, where it enters the wet cultivation below the Huchuchakenhalli Tank. from 162nd to 178th chain the channel crosses this wet cultivation, and alteration of alignment will here be necessary, which will decrease the length of channel by 528 feet—the whole length of the channel (528 feet in length) of this re-alignment must be carried above ground level.

(G). From 175th chain to 241st chain the channel runs through—dry cultivation—from 241st to 250th through black cotton soil, where an alteration of alignment is necessary—from 250th to 289th the channel passes through dry cultivation, and from this point it follows the Railway up to 317th chain—from 270th to 305th chain the alignment should be altered and a further saving in length of over 6 chains can be made.

(H). At 305th chain the channel leaves the Railway and runs to the left, passing over very broken ground between 330th and 332nd chains and crossing the kodi nala of Kumbarhalli Tank at chain No 335—the channel between 330th and 362nd chains should be carried higher up and kodi channel should be crossed 200 feet above present crossing. (An acqueduct 20 feet in length will be wanted across the Kumbarhalli drainage)

(I). From 352nd to 376th chains the line of channel runs through the wet cultivation below the Kumbarhalli Tank and at 380th it crosses the combined kodi nala of the Banavar and Ganigarhalli Tanks. An acqueduct 50 feet in length is here necessary.

(J). At 385th a rather deep nala is crossed, but a little higher up, it tails off, and lower down forms an irrigation channel: consequently all that is necessary is to throw up a dam across it and construct a tunnel for irrigation on the left bank.

(K). From 386th chain the ground rises rapidly on all sides, and the channel cannot be continued beyond the 390th chain without necessitating deep cutting, which would add greatly to the cost of the settling reservoirs which are proposed to be placed at end of delivery channel.

57. Approximate cost of delivery channel :—

		C. Yds.	Rs
(*a*)	Earthwork excavation and refilling—		
	For first 660 feet from end of Channel up to line with weir	17,954	
	Beyond line of weir up to commencement of chain No 1—1056 feet	24,562	
	From 1st to 50th chain 3,300 R. ft	20 955	
	Total.....	63,471	
	At As. 3—6 =		13,884
(*b*)	Delivery channel as per Section A— From end of tunnel to 50th chain 5,016 R. ft. at Rs 10—6 =		52 041
(*c*)	Ventilating shafts and silt traps— From end of tunnel to 50th chain No. 8 at Rs 175 ... =		1,400
(*d*)	Delivery channel as per sketch B. 18,810 feet at Rs. 4 ... =		75,240
	Fencing line and drainage 4'51 miles at Rs. 300 per mile . . =		1,353
	Compensation for lands, 12 acres at Rs. 35 ... ... =		420
	Aqueduct—		
	No. 4 aggregating 1278 R. feet inclusive of cost of channel at Rs. 4 per R. feet ... ... =		5,112
	Silt traps—		
	One at every 10 chains, No. 34 at Rs. 10 ... ... =		340
	Total cost of delivery channel		1,49.790

58. *Settling tanks.*—At the end of delivery channel it is proposed to have two settling tanks, each to hold a day's supply. The tanks will be 211 feet square at bottom and 10 feet in depth with slopes of 1 to 1, and will be floored and lined with $1\frac{1}{2}$ feet of brick in surki, plastered throughout with surki mortar

The site selected for the construction of tanks is a favorable one, there being four feet of "red soil" with clay underlying it.

The cost of the work will be as follows:—

	Rs.
Earthwork excavation 27,876 C yds. at As. 2 = ...	3 484
Brick in surki 88,854 C. ft at Rs. 3=	16 660
Plastering with surki mortar 592 36 sq at Rs 3	1,777
D. Pumping well, constructed with Portland cement L. S.	150.
E. *Land.*	
2 acres at Rs. 36	72
Total Rs...	22,113
For two tanks Rs.	14,286

59. *Pumps and Engines.*—(A.) Will be fitted up immediately above the settling ponds at a distance of 150 yards from the Southern Mahratta Railway line.

(B.) Allowing 24 as maximum diameter of pipe main and that it is necessary, with reference to economy in cost of distribution, to have the floor of service reservoir at R. L. 3,055, the lift will be 357 ft. as per details below.

(C.) Level of service reservoir....R. L. 3,055·00.

Head necessary to discharge 500,000 C. ft. in a day of 13½ hours in 24 piping, the length of main being 36,900 ft.		74 00
Loss in filtering and service reservoirs		10 ft.
	R L. ...	3,139 ft
Floor of Settling Tanks R. L		2,782 ft.
	Difference...	357 ft.
Pumping main 8,580 feet in length, 24 diameter, to discharge 617·3 C. ft. per minute head required		17 ft.
	* Total Lift..	374 ft.

(D.) The Agent of the Worthington Pumping Company, Calcutta, has been addressed regarding cost inclusive of delivery and erection of two triple expansion engines with Babcock boilers, each engine to lift 3,858 gallons per minute to a height of 374 ft. through 1¼ miles of 24" rising main and on receipt of † reply, the actual cost of this sub-head of work will be given, but in meantime to allow of completion of approximate estimate, a sum of Rs. 2,00,000 has been allowed.

(E) In order to reduce the lift as much as possible, pumping for 13½ hours per day has been allowed; but, as in any case relays of men would be necessary, this as well as the additional pumping of 7 hours twice per week, necessary to keep up the supply and allow of a day's rest on Sundays can be done without difficulty.

60. *Rising Main.*—

(A) Will start from the 398th chain and be laid in a straight line to the top of the Banavara Hill, (517th chain) where it will be joined on to the stand post—at the 416th chain. The line of piping crosses a nala, 50 ft. in width and 8 ft. in depth, from whence up to the Railway (421st chain) it runs over broken ground—the line crosses the Railway diagonally at Telegraph post 200—191, where it is in cutting 4 ft. in depth, and a tunnel will be necessary—at the 412nd chain the line of piping crosses two ravines, and will have to be carried on masonry pillars for the distance of two chains—from this to top of hill there is not any obstruction of much consequence

(B) The main will be of 24" socket and spigot piping and 8,580 ft. in length. The thickness of the piping being 1 inch, the weight inclusive of socket will be 2·37 Cwt. per ft. run.

85,80 x 2 37=20,334 Cwt. at 7—12—0	..	...	...	1,57,588

* Deduct 20 ft. for suction.

† Telegram despatched and reply to following effect received —

"We can only quote for high pressure and compound, all triple expansion made under royalty by "S. Simpson & Co, London"

In reply to subsequent telegram asking for quotation for compound Engines, the Agent telegraphed—

"We have cabled for special quotation and will wire you on reply."

C. *Laying Pipes.*—

8,580 R. ft. of 24" piping at Rs. 1	8,580
Grand total of rising main..	166,168

61. *Engine and Boiler house with Chimney.*—

Lump sum	20,000

62. *Quarters for Establishment.*—

Lump sum	16,000

63. A. *Stand-Post.*—To be 42 ft. in height above top of Banawar Hill the R. L. of which is 3,097·64.

B. Flanged pipes 24' diameter and $1\frac{1}{8}$" thickness of metal to be used. Special castings throughout will be necessary, as bends at base must have proper seating and flanges of piping must have lugs.

C. For 30 ft. in height the stand-post will be carried up in a masonry tower, which will serve as a watchman's post and signalling station; consequently struts and braces will be requisite for the upper 12 ft. only

64. *Details of cost*—

Tower 8 feet octagonal.

A.	Stone in chunam foundations	256 ft.	
	Basement	57	
	Superstructure	1,282	
	Total...	1,595 C.ft.	
	at As. 3—6=Rs.	349	
B.	Doors and Windows	Rs.	50
C.	Roofing slabs and Terrace	Rs.	30
D.	Ladder with trap doors	Rs	50
	Total Rs.	479	

E. 24" flanged piping.
F. 68 feet straight pipes with special flanges 30 ft of bends &c.
Total 98 ft. 2·75 Cwt. per ft.=$269\frac{1}{2}$ Cwt. at Rs. 10—8 Rs. 2,830

Fixing piping 98 ft. at Rs. 2	196
Grand Total, Rs...	3,505

65. *Delivery Main.*—A. There is a nasty dip just beyond the brow of the hill, but this can to some extent be avoided by a slight detour to the west.

B. At 783rd chain the line crosses the Southern Mahratta Railway, and at 893rd chain, the Bangalore-Hindupur-Railway—from 864th to 881st chain, the line passes through the bed of the Yesvantapur Tank, but no deviation will, I think, be necessary on this account, as the soil in bed of tank is hard and clayey.

C. The total length of the main is 36,960 ft. in which for 18,678 ft or more than half the length, the head is less than 140 ft. but no alteration in thickness of metal in pipes has been made on this account, as 1" is the least thickness that can be allowed for 24" piping with regard to safety of carriage.

66. *Cost of Main.*—

36,960 R. ft. of 24" piping with 1" thickness of metal weight 2 37 Cwt. per ft. run—87,595 Cwt. at Rs 7-12-0 per Cwt. Rs. 6,78,861

B. Laying pipes 36,960 R. ft. at 1 Rupee per ft. = 36,960

C. Air valves 5 at Rs 200 1,000

D. Scour valves 6 at Rs. 150 900

E. Sluice valves 4 with spigot and socket faced Tail Pipes at Rs. 520 2,080

F. Reflux valves 6 at Rs. 500 3,000

Grand Total for Delivery Main...7,22,801

67. *Filtering Reservoirs.*—

A. Will be similar in construction to the settling tanks, *i. e.*, reservoirs sunk below ground level, floored and lined with $1\frac{1}{2}$ ft. of brick in chunam.

B. Three each 144 ft. square, two of which will filter a day's supply at the rate of 75 gallons per sq. ft. in 24 hours.—The filtering strata to consist of sand, charcoal and stone jelly 2'—6"—4" and 1 ft. in depth respectively.

68. *Cost of Reservoirs*—

A. Earthwork excavation—

Rs

11,271 Cubic yards at 2 annas 1,409

B. Brick in surki mortar—

47,109 C. ft. at 3 annas 8,833

C. Plastering with surki mortar—

399 7 Squares at Rs 3 1,197

Total.....11 439

For 3 Reservoirs.....34,317

69. *Service Reservoirs*—

A. Construction to be similar to that proposed for filtering reservoirs, with the exception that it will be covered with stone slabs carried on stone pillars 1 ft. sq., fixed 9 ft. apart from centre to centre, which will be founded on stone slabs, laid $1\frac{1}{2}$ ft. below foundation of floor of reservoir.

B. Reservoir to be 10 ft. in depth and to store 3 days' supply or 1,500,000 C. ft.

70. *Cost of Service Reservoirs*—

A. Earthwork Excavation—

Rs

72,150 C. Yds. at 2 annas 9,019

B. Brick in Surki—

277,200 C. ft. at 3 annas 51 978

C. Plastering with surki mortar—

1882·80 Sqs at Rs. 3 per Square 5,648

D. Stone slabs for foundation of pillars—

12,420 Sq. ft. at 3 annas 2,329

Carried forward.....68,974

Brought forward... Rs. 68,974

E. Stone pillar 14′ × 1′ × 7″ (dressed)—

	Rs.
No. 2,070 at Rs. 5	10,350

F. Stone girders 9′ × 1′ × 8″—

No. 2,000 at Rs. 3—8—0	7,000

G. Stone slabs (9′ × 1½′ × 4½″) sides dressed—

186,979 Sq. ft. at 3 annas	35,059
Grand Total.....	1,21,383

71. *Distribution*—

Rupees 3½ per head for population of 250,000 ...	8,75,000

72. *Compensation.*—

A. Land thrown out of cultivation below Hessarghatta Tank—

	Rs.
Wet land 202½ acres at Rs. 75	15,187
Garden land 110½ do 100	11,050
Total.....	26,237
Deduct probable receipts by sale of land for dry cultivation, 313 acres at Rs. 36 . ..	11,268
Net compensation to be paid ...	14,969

B. Land thrown out of cultivation below Byata Tank—

Wet land 75½ acres at Rs. 75	5,662
Garden land 10½ do 100	1,050
Total.....	6,712

Land thrown out of cultivation below Kakol Tank—

Wet land 123¾ acres at Rs. 75	9,281
Garden land 11¼ do 100	1,125
Total.....	10,406

C. Land submerged by raising weir of Hessarghatta Tank—

Wet land—see statement of wet land below Byata and Kakol tanks—dry land *643 acres at Rs. 36 per acre	23,148

* In addition to this 158 acres of wet lands now lying fallow below the Byata and Kakol tanks will be submerged.

† Details for the five minor tanks cannot be given as Revenue statements for same have not yet been received from the Revenue authorities.

† Revenue statement for four tanks since received.

D. *Somanahalli.*—Land thrown out of cultivation—

	Rs.
Wet land 44 acres at Rs. 75	3,300
Garden land 2 do 100	200
Total.....	3,500

E. *Chik Devanpur*—

Wet land 28 acres at Rs. 75	2,100
Garden land 2 do 100	200
Total ...	2,300

Carried over... Rs. 61,035

Brought forward...Rs. 61,035

F. Devarakunte Tank—

	Rs.
Wet land 25 acres at Rs 75	1,875
Garden land 6½ do 100	650
Total.....	2,525

G Arasinkunte—

Wet land 19½ acres at Rs. 75	1,462
Garden land 1½ do 100	150
Total.....	1,612

H. Jumbinkunte—

Wet land at Rs 75	
Garden do 100	
Grand Total.....	65,172

73. *Loss of Revenue*—

Particulars with regard to this item can only be given for the Hessarghatta, Byata and Kakol Tanks, as Revenue statements for the five minor tanks have not yet been received, notwithstanding several reminders have been sent to the Revenue authorities on the subject.*

Hessarghatta Tank—

	Rs
Wet land	1,216
Garden land	628
Total....	1,844

Byata Tank—

Wet land	493
Garden land.	78
Total.....	571

Kakol Tank—

Wet land	792
Garden land	51
Total.....	843
Grand Total.. ...	3,258
Deduct probable revenue from land below Hessarghatta Tank, if leased as dry land, 313 acres at Rs 2	626
Net Loss.....	2,632

Sonnamhalli—

Wet land	220
Garden land	15
Total.....	235

Chik Devanpur—

Wet land	142
Garden land	19
Total.....	161

*Since received for other tanks.

Devarakunte—

		Rs.
Wet land	... ...	112
Garden land	... .	12
	Total.....124	

Arasinkunte—

Wet land	... ...	82
Garden land	... ...	3
	Total...85	

Jumbinkkunte—

... ...		...
.. ..		...
	Total.....	

Add loss of Revenue on 4 tanks noted above ...	605
Do 643 acres of dry land submerged	965
Grand Total.. ...4,202	

74. *Abstract of Cost of Project.*—

Present value of 8 tanks comprising project (See Statement page 19)	1,04,795

Head works—

Bund	66,069
Waste weir	33,543
Do	2,020
Water tower	37,760
	2,44,187

Delivery works—

Masonry channel	1,19,790
Settling Tanks	14,286
Pumps and Engines	2,00,000
Rising Main	1,66,168
Engine and Boiler house with chimney ...	20,000
Quarters for establishment	16,000
Stand post	3,500
Deliver Main	7 22,801
Filtering reservoirs	34,317
Service reservoirs	1,21,283
Town distribution	8,70,000
	2? 5?,250

Incidental charges—

Compensation for land	6 [illegible] 2
Contingencies at 5 per cent . ..	1,29,87
Establishment 15 per cent on Head works, masonry channel, settling tanks, engine and boiler house quarters for establishment, Stand post, filtering and service reservoirs	25,020
Establishment 5 per cent on other items ...	9?,198
Grand Total.. ...Rs	29,?0,098

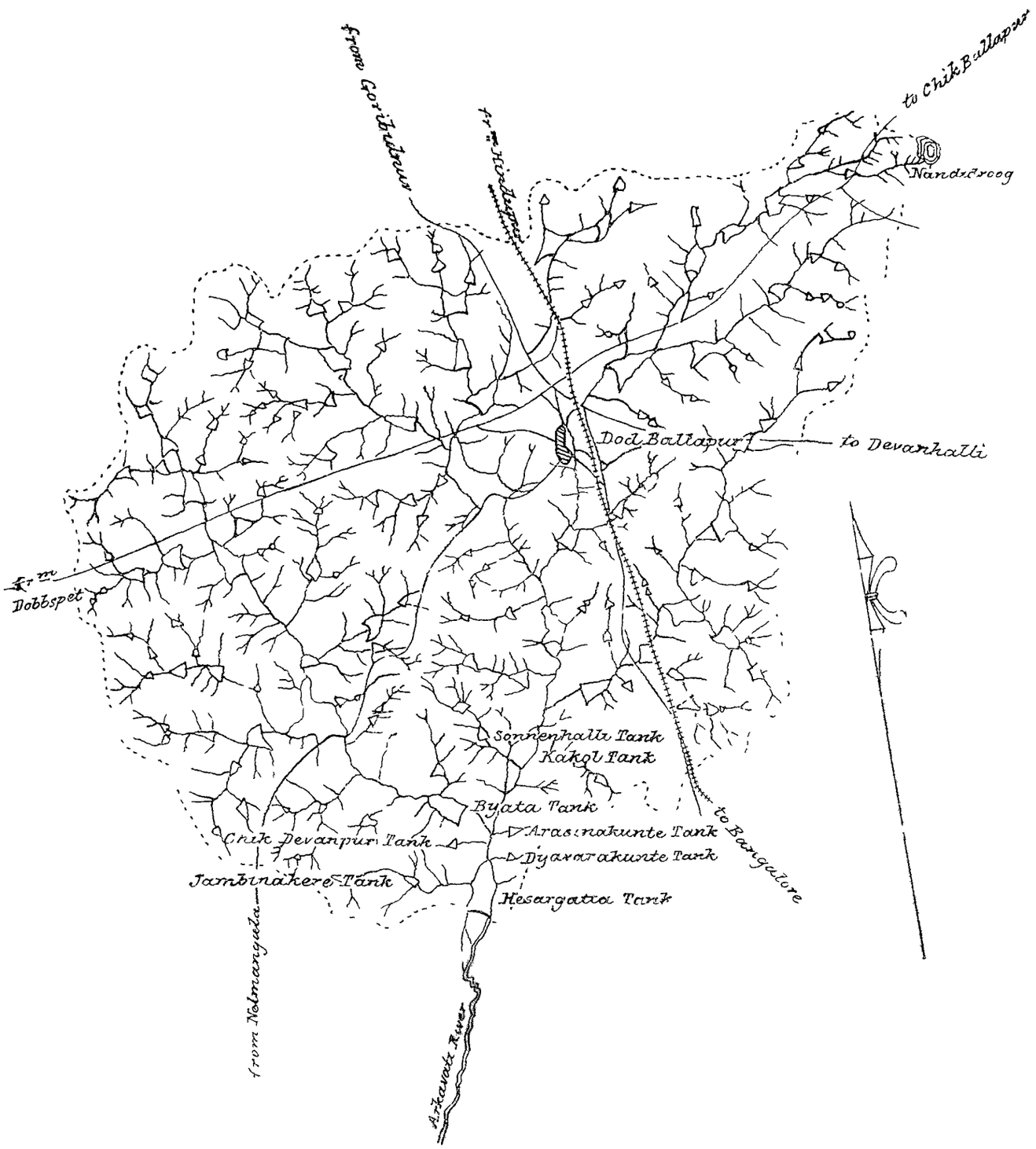
R. T. SCALDWELL,
Executive Engineer, Bangalore Division.

10th January 18

ysore Govt, Central Press, Bangalore.—19-2-93.—50

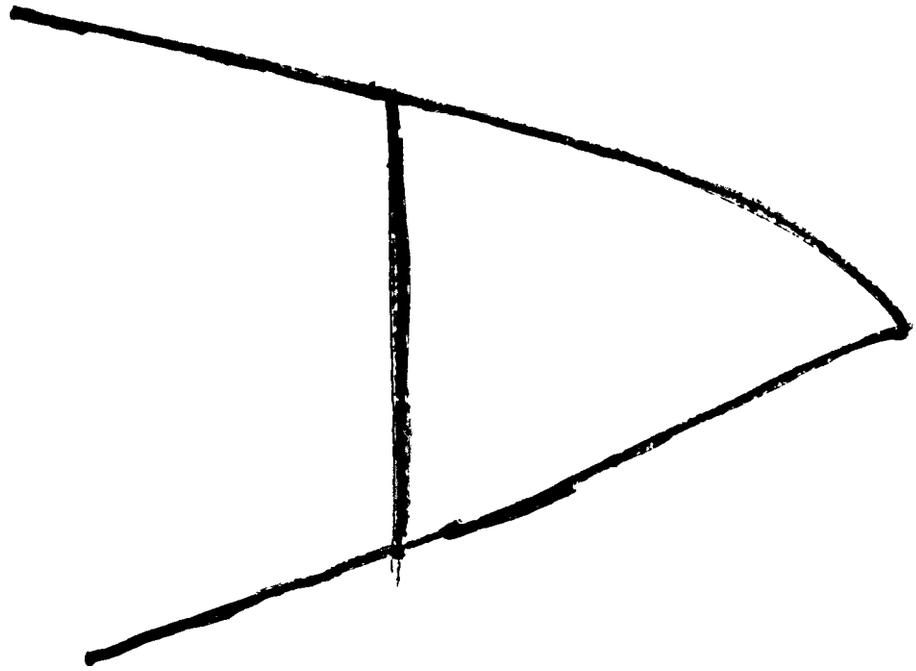
HESARGATTA TANK SERIES

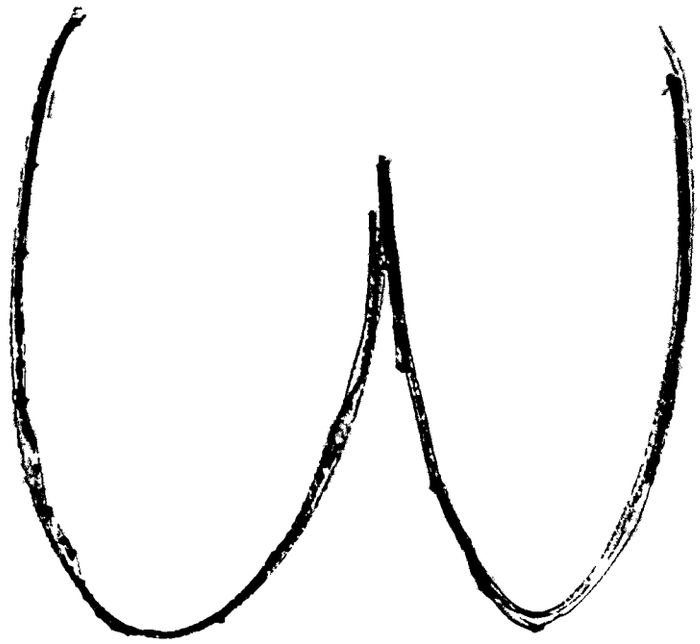
Scale 1 Inch = 3 Miles

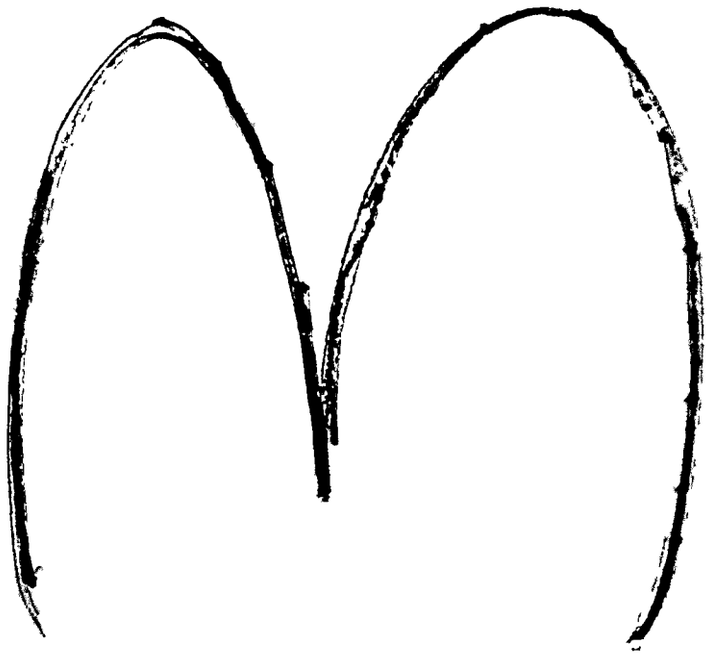


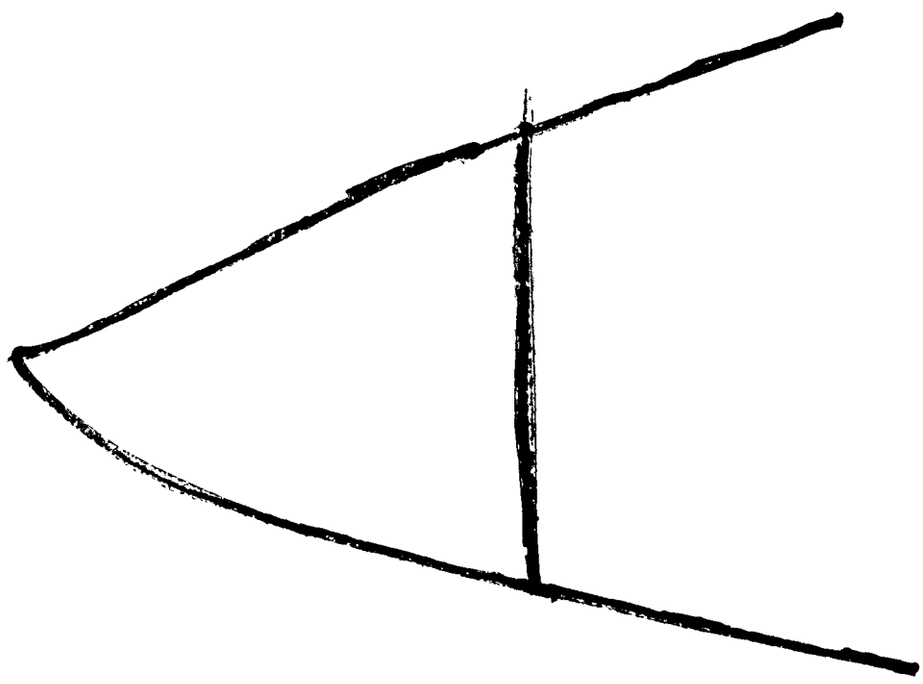
No. of Tanks - - - - 187

Catchment area 212 Sq.r Miles









Fair Draft

No. [illegible] of Camp,
Sivaganga 8th Febr 43.

To,

The Superintendent
Mysore Revenue Survey
Bangalore.

Sir

I am directed by the Dewan to request the favor of your furnishing him with information upon the points noted in the accompanying statement regarding the tanks named there. It will be noted that information is required regarding total irrigable area under, and the water spread of each of these tanks the portions of the irrigable area situated in each village and the

assessment thereon
shown under the
heads, "Wet" and "Garden",
the portions of water
spread in each village
The Dewan will be glad
to have at the same
time a tracing --
from the village maps
showing all the Villages
and tanks concerned
the irrigable area
and water spread
under each tank --
and the boundary
of each village
2 Information as
above is required --
urgently in connection
with the Hesaraghatta
Scheme for the water
supply

supply of Bangalore and I am to request that the statement and map may be prepared with great accuracy and sent to the Secretary's Office as early as possible

I have &c.

Under Secretary

Mysore Revenue Survey Office
Bangalore 27th. Feby: 1893

Recd. 28/2
6 P.M.

From The Asst Supt. in charge
Revenue Survey Hd Qrs office

To

L. Anantaswami Rao Esqr
Under Secretary to the Dewan
of Mysore

Sir

With reference to your letter No $\frac{A}{D\,H\,O}$ of the 8th Instant, to the Superintendent Mysore Revenue Survey, I have the honor in compliance with instructions received from that Officer, to forward a Statement showing the area and assessment of Wet and Garden lands under the Tanks named in the State=ment sent with your letter referred to above, and also the Waterspread or Catchment area of each Tank. With regard to the latter, I beg to state that it would be impossible to furnish any information from this Office, in the absence of a proper map, showing by Contour lines

tt

the features of the Country on a sufficient=ly large scale. The Revenue Survey maps are useless in this respect, and the Topl. Survey sheets are on too small a scale. Recourse was therefore had to the map in the Ex. Engineer's Office, and the Waterspread as shown in the accompanying Statement is based on details obtained from this map, and must be considered as approxi=mate only.

2 The Waterspread of each Tank shown in the Statement does not agree, with that obtained from the Ex. Engineers Office, though the total area is very close, as will be seen from the figures set down in the margin.

	acres
Rev. Survey	16,524
Ex. Engr.	16,637

3 . I have also to intimate the despatch in a separate parcel, of a tracing of a map of 38 villages, which come within the Catchment area of Hesargatta Tank, and which shows the irrigable area under each Tank. It was found impossible to show on the map the boundary

Waterspread of each Tank, as the position of the Tanks on the Exc: Engineer's & Rev: Survey maps did not agree, and as stated before there is a total absence of Contour lines on either map to enable me to lay down the boundary of Waterspread with any accuracy.

I have the honor to be

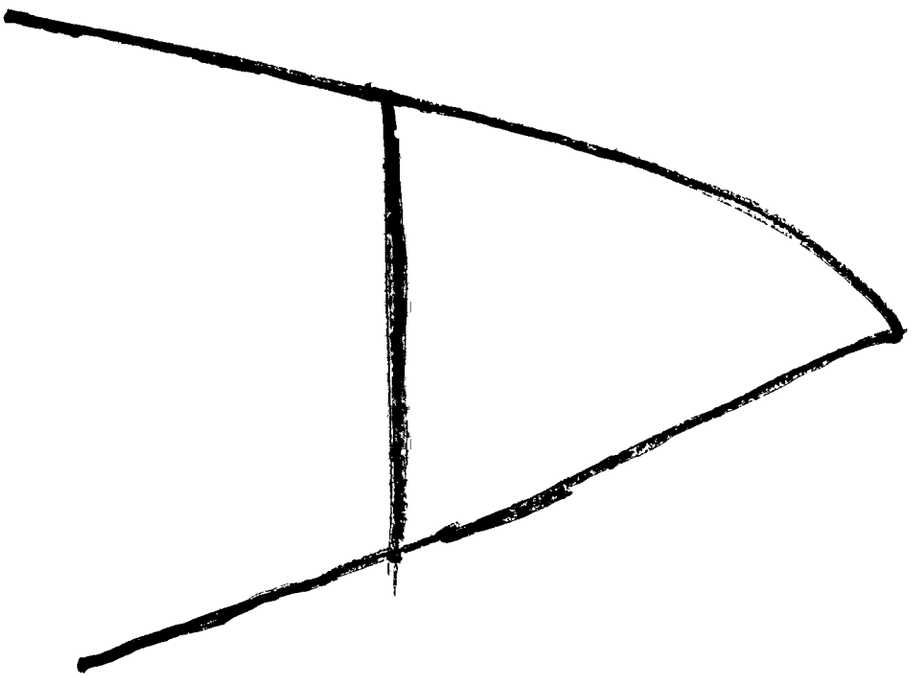
Sir

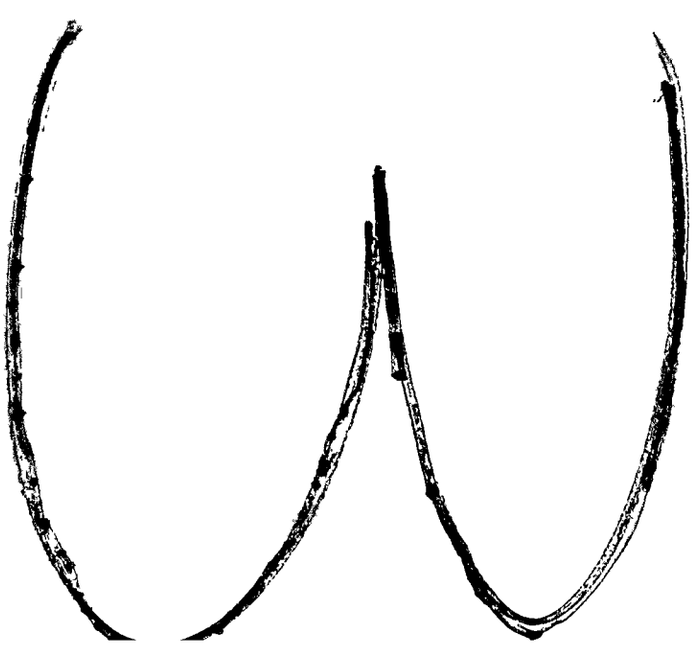
Your most obedt. servant

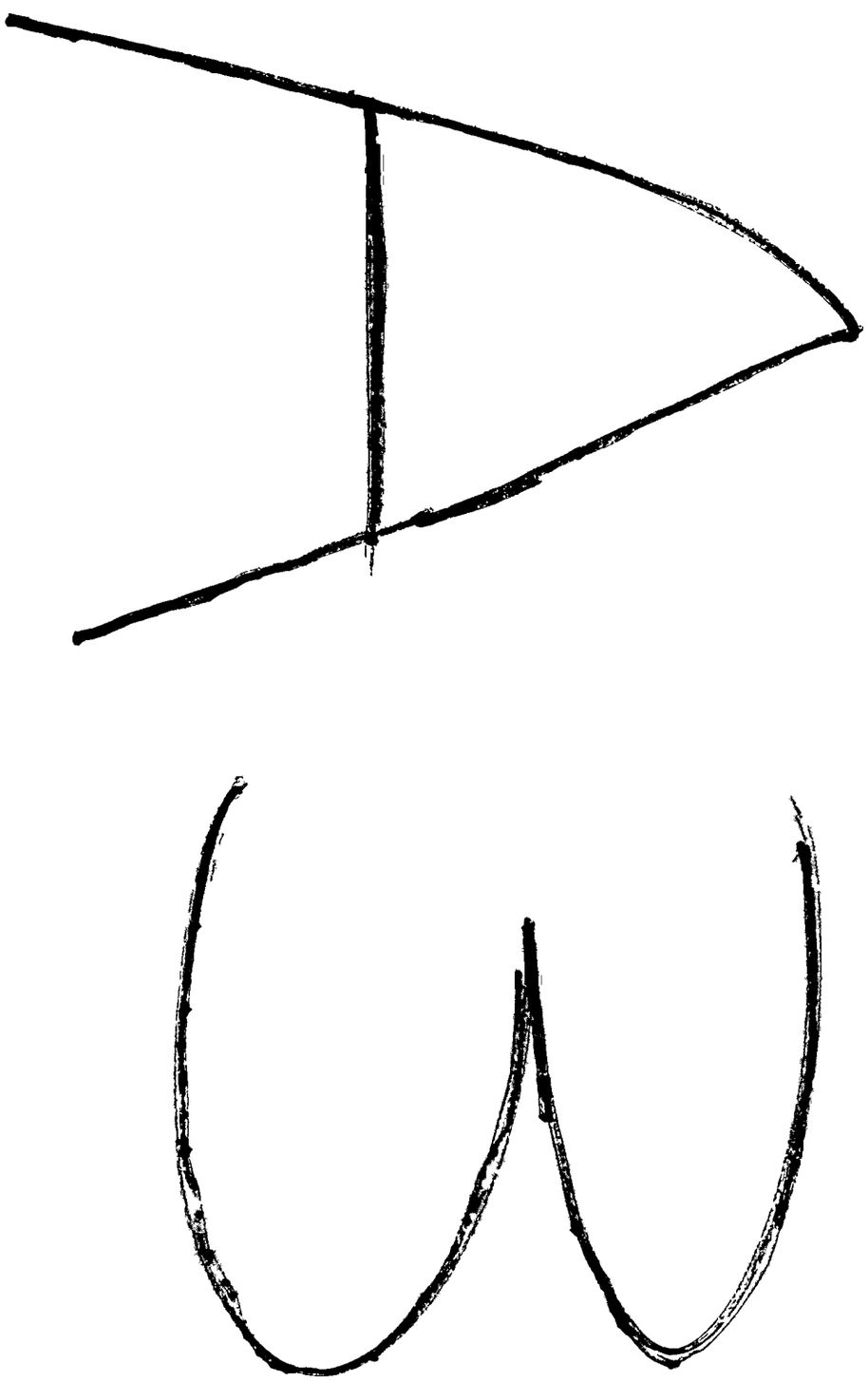
Jas. L. Mackay

Asst. Supt. Rev

Survey.







D. P. W.

Memo

In a Statement furnished to the Under Secretary (by the Assistant Superintendent in Charge of the Revenue Survey Head-Quarter Office, with his letter No. 444, dated 27th February 1893, information is given regarding the water spread of, and irrigable area under, the 12 tanks comprised in the proposed Hesarghatta water Supply Scheme. This information is compared below with similar information given by Mr Scaldwell in Statements A and D attached to

to paras 34 and 37 of his Preliminary report of 10th January 1893.: ——

Name of Tank	Water Spread		Irrigable Area	
	According to Mr. Scaldwell's Report	According to Survey Assistant Superintendent	According to Mr. Scaldwell's Report	According to Survey Assistant Superintendent
Hesargatta	336·53	1675·24	322·12	299·19
Byatta	157·59	6425·30	233·17	311·35
Kakol	320·55	3215·31	363·3	325·39
Sonnenahalli	18·97	642·39	52·9	52·22
Chikdevanpur	16·86	1062·14	35	18·0
Jambau Kere	38·44	1312·9	Not Stated	100·8
Devar Kunte	16·84	496·11	31·50	25·6
Arsin Kunte	14·40	442·2	21 18	20·38
Shanbhoganhalli	7·32	412·0	28	21·6
Sudamarnahalli	22·14	839·8	32	32·12
Anikere	3·11	Not Stated	39	33·35
Yattikere	66·40	do.	70	28·8
Total	1019·15	16524·8	1228·17	1269·28

The areas of water Spread given by the Survey Assistant are all very incorrect indeed, owing probably to some misconception on his

his part. Possibly he has put down Catchment area instead of the actually Sub-mergible areas. The differ-ence in irrigable areas is also considerable.

Under Such Circum-stances the Superintendent Revenue Survey will be requested to be so good as to have every figure in the Statement in question very Carefully Scrutinized, to cause to be prepared a Correct revised State-ment and to forward the Same at as early a date as possible

I would also like to have a similar statement for the Jodi tank of Aivarkhandpur and of all tanks draining into it. The D.P.W. will send Colonel Grant a list of these tanks for ready reference.

15th April 1893
Camp Mysore

Res. Survey Sub-remitts No. 1074 of 26. 4. 93

Note No. 740 of 15-4 93.

No. 1598/254 of 17/4/93
Copy to Mr. Sealdwell for information and attention to the concluding para of the note.

Record

Offg: Secretary

DPW memo.

In a statement furnished to the under Secy by the Asst. Supt. in charge of the Rev. Survey Hd. Qr. Office with his letter No. 444 of 27 Feby 93. information is given regarding the water spread of, and irrigable area under, the 12 tanks comprised in the proposed Hessarghatta water supply scheme. This information ~~thus given~~ is compared below with similar information given by Mr. Scaldwell in statements A & D. attached to paras 34 & 37 of his Prelim. report of 10 Jan. 1893:—

Name of Tank.	Water Spread		Irrigable area	
	Accg to Mr Scald. well's report	Accg to Survey Asst Supt.	Accg to Mr Scald. well's Report	According to Survey Asst Supt.
Hessarghatta	336.53	16[illegible]	[illegible]2.12	[illegible]
Byata	157.59	6425.38	233.17	311.35
Kakol	320.55	3215.31	363.3	3[illegible]
Sonnenahalli	18.97	642.39	52.9	52.22
Chikdevarpur	16.86	1062.14	35	18.[illegible]
Jambankere	38.44	1312.9		100.8
Devarkunti	16.84	496.11	31.50	25.6
Arsinkunti	14.40	442.2	21.18	20.38
Shanbogan halli	7.32	412.6	28	[illegible].6
Budamarnahalli	22.14	839.8	32	32.12
Arikere	3.11	Not stated	39	33.3[illegible]
Yettikere	66.40	"	70	28.[illegible]
Total	1019.15	16,524.8	1228.17	1269.28

The areas of water spread given by the

Survey asst. are all very incorrect indeed
owing probably to some misconception on
his part. Possibly he has put down catchment areas
instead of the actually submergible areas.

The difference in irrigable areas ~~though~~
~~between the two statements~~ is also
~~not so~~ considerable -

Under such circs the Supt. Res
Survey will be requested to be so
good as to have ~~the entire~~ every figure in the ~~in question~~ statement
in question very carefully scrutinized, to cause to be prepared
a correct ~~stat~~ revised statement and to
forward the same at as early a date
as possible.

~~[illegible]~~

I wd. also like to have a similar
~~correct~~ statement for the Jodi tank of
Ainarkhandpur & of all tanks draining
into it - The D.P.W. will send Col Grant
a list of these tanks for ready reference -

(Sd) K S

119
D H.O %

Col. J. P. Grant for needful early
action

(Sd) K. Sheshadri Iyer
Dewan

15. iv. 93

~~If Hes~~

The actual occupied area under the 12 tanks comprised in the Hessarghatta Water Supply scheme is returned ~~if~~ as follows

Name of Tank	~~wet garden~~ acres wet	acres garden	acres Total	Total R.
[illegible]	202.[illegible]	[illegible]	31[illegible].6	18[illegible]
[illegible]	75.[illegible]8	[illegible]	85.3[illegible]	574
Kabol	123.33	11.20	[illegible]	8[illegible]
[illegible]	44.9	1.3[illegible]	[illegible]	235
Cl. [illegible]	27.37	2.13	3[illegible].0	[illegible]
[illegible]				
[illegible]	25.6	6.24	31 30	[illegible]
[illegible]	19.[illegible]	1.[illegible]	21.18	84
9 - Shrub Coconut [illegible]				
10 - Budamaran				
11 - Arikere				
12 - [illegible]				

~~The whole of the~~

The Deps. Comr. will submit in consultation with the E.E. at a very early date a statement of the compensation required for the whole of the occupied lands irrigated ~~under~~ by the 12 tanks in question. ~~for these lands~~ - The statement shd. show separately such of the above mentioned lands as are ~~the lands~~ likely to be submerged by the proposed enlargement Hess & their value. Mr. B.G. Kristnengar Asst. Comr. shd. be deputed to investigate the claims for compensation & to settle them on fair & reasonable rates, with [illegible] instructions as the Dep. Comr.

Enter at end.

may consider necessary - no actual payments Shd. be made before the Govt. pass orders upon the Stts. now called for.

When I was last at Hessargatta I was assured by the Asst. Comr. in attendance that orders have already been issued ~~to~~ prohibiting the ~~permanent~~ permanent grant of Occupancy rights in lands likely to be required for the work in question - I hope these orders are being duly carried out.

As regards garden lands under the Hessargatta tank ~~it may~~ the occupants are probably willing to keep them ~~for~~ on the ground ~~they wd. be content with~~ that the percolation from the tank is sufficient for them & though they need no ~~& wd. not demand~~ direct irrigation. This point Shd. be investigated - whatever be the result of this investigation, ~~their~~ compensation on their account Shd. be separately included in the statement to be submitted -

Villages and Dry lands which have to be acquired on the ground of possible submersion ~~Shd. be assessed~~ (~~Say those~~ Villages situated within ~~15'~~ 10 or 15' of the proposed W.W. level ~~Shd. be~~ & Dry lands within 5' or 8' as the ~~Hy.~~ Ch. Engr. may decide) Shd. be separately assessed - The Villages removed Shd. be built outside the Catchment of Hessargatta & Aivankhand pm Tanks

3121/DHo. of 15-4-93 Copy to D.C. Bangalore for immediate infor. & guidance.

15/4/93.

Memorandum

S. P. W.

The actual occupied area under the 12 tanks comprised in the Hessarghatta Water Supply Scheme is returned as follows:-

No.	Name of Tank.	Acres.			Total Revenue.		
		Wet	Garden	Total			
1.	Hessarghatta	202.27	110.19.	313.6.	1844	4	0
2	Byata	75.18	10.17.	85.35	574	-	-
3	Kakol.	123.33	11.20	135.13.	842	4	0
4	Soumenhalli	44.9	1.36	46.6.	235	-	-
5	Shikdevanpar	27.37.	2.13.	30.10	162	-	-
6	Jambenkere	not stated					
7.	Devarkunte.	25.6	6.24	31.30	124	-	-
8.	Arsinkunte	19.29	1.29.	21.18	84	-	-
9.	Shanbaghanhalli						
10	Budamanhalli						
11	Arikere	not stated					
12	Yettikere						
	Total	518.39	144.38	663.37	3,865	8	

The Deputy Commissioner will submit in consultation with the Executive Engineer at a very early date a statement of the compensation required for the whole of the occupied lands irrigated by the 12 tanks in question. The statement should show separately such of the above mentioned lands as are likely to be submerged by the proposed enlargement of Hessarghatta and their value

When I was last at Hessarghatta I was assured by the Asst. Commissioner in attendance that orders have already been issued prohibiting the permanent grant of occupancy rights in lands likely to be required for the work in question. I hope these orders are being duly carried out.

As regards garden lands under the H.C. essanghatta Tank the occupants are probably willing to keep them on the ground that the percolation from the tank is sufficient for them and that they need no direct irrigation. This point should be investigated. Whatever be the result of this investi-gation, compensation on their account should be separately included in the statement to be submitted.

Villages and dry lands which have to be acquired on the ground of possible sub-mersion (villages situated within 10 or 15' of the proposed Waste Weir level and dry lands within 5' or 8' as the Chief Engineer may decide) should be separately assessed. The villages removed should be built

outside the catchment of Hessar-ghatta and Aiwarkandpur Tanks.

Mr. B.G. Krishniengar, Sub Division Officer should be deputed to investigate the claims for compensation and to settle them on fair and reasonable rates, with such instructions as the Deputy Commissioner may consider necessary. No actual payments should be made before the Government pass orders upon the Statements now called for.

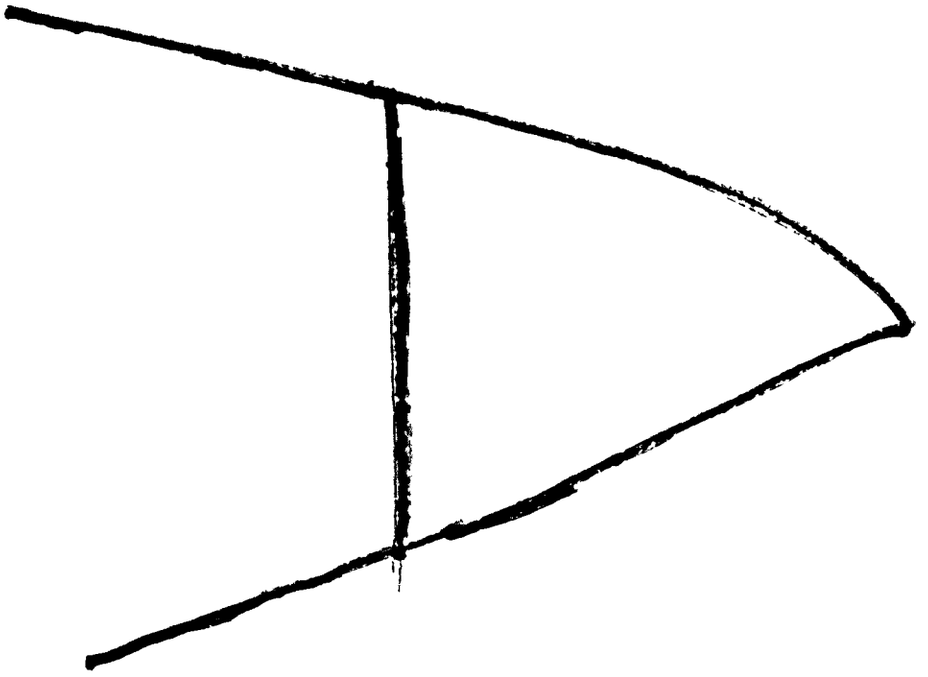
(signed) K. Sheshadri Iyer,
Dewan

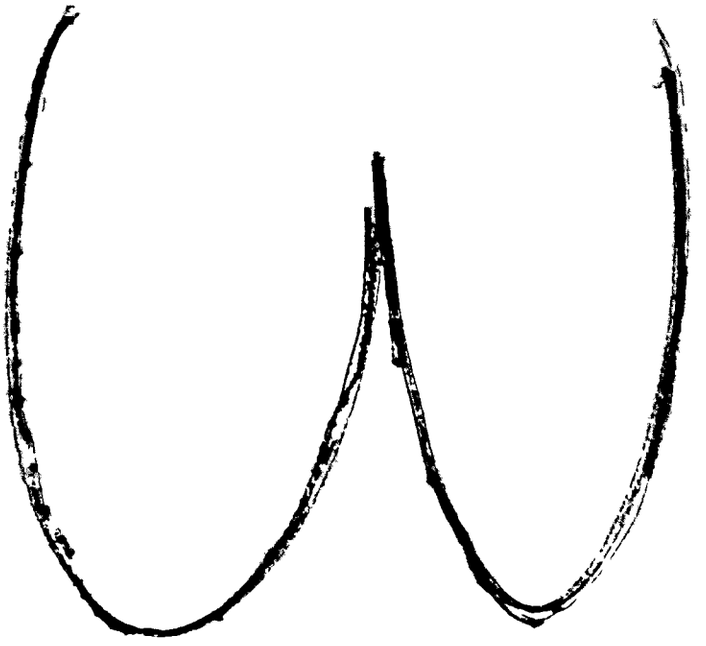
No. 121/DHO of 15th April/93

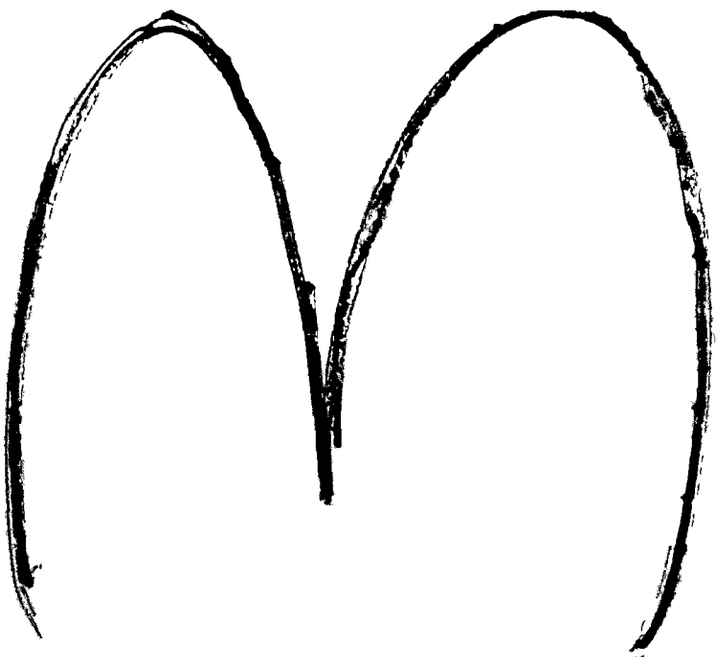
Copy forwarded to the Deputy Commissioner, Bangalore District, for immediate information and guidance.

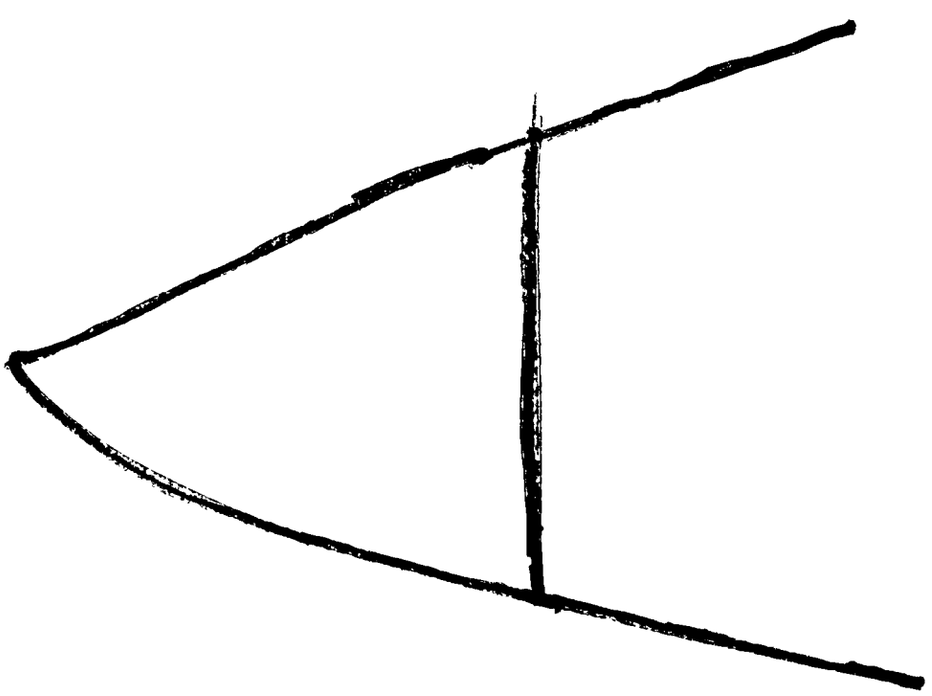
By order

Under Secretary.









No. 47.

SECRETARY'S
REG'D. NO. 2043
26 APR. 93
MYSORE P. N. 3.

1893

From The Suptt Mysore Red Survey

To The Secretary to the Govt ~~The Revenue Survey,~~ of Mysore. P W D

Dated } Bangalore
Despatched } 26 April /93

Received.

Enclosures No. 2

General No 1074 } 1893.
No.

Has Memo No 119 of DHO
15th Instant

Begs to forward the accompanying Memorandum No 1073 of the 26th idem re-garding the water spread of, and irrigable area under the 12 Tanks comprised in the proposed Hesargatt Water-supply Scheme

[signature]
Suptt Mysore Red Survey

D. P. W. Memo No. 119/D&O, dated 15th April 1893.

In the above Memo the figures, in a statement furnished to the Under Secretary by the Asst. Supt. in charge of the Revenue Survey Head Quarter Office with his letter No. 444 of 27th Feby. 1893 regarding the water spread of, and irrigable area under, the 12 tanks comprised in the proposed Hesarghatta water supply scheme, are discussed and certain errors and discrepancies are pointed out

A revised Statement is herewith submitted with the following remarks.

Tank.	By Survey a. gtas	In Mr. Scaldwell's Report a. cents
esarghatta	425. 32	336. 53
Byata	175. 24	157 59
Kakol	280 21	320. 55
Sonenhalli	25 16	18 97
Chikdevanpur	25 26	16. 86
Jambankere	42. 26	38. 44
Devarkunti	20. 13	16. 84
Arsinkunti	21 26	14 40
Shanboganhi	20 19	7 32
Budamanhi	30. 15	22 14
Arikere	29 9	3 11
Yettikere	51 15	66 40
	1149. 2	1019. 15

Waterspread The apparent errors in the areas of waterspread originally furnished by Mr. Mackay are, as correctly surmised by the Dewan, due to Mr. Mackay having, under a mistaken idea of what was required, put down catchment instead of water spread

The areas of water spread now given are taken from our village maps. They compare with those entered by Mr. Scaldwell as shown in the margin I believe the Survey areas are by far the more correct, indeed, in some cases, the areas entered by Mr. Scaldwell must be wrong.

Irrigable Area. The total irrigable area now shewn is only 3 a. 32 g less than the area shewn in the previous statement; 27th Sept. 25 a. 4 g shewn in previous Statement as under Byata are now under Kakol. With the above exceptions the first Statement was correct.

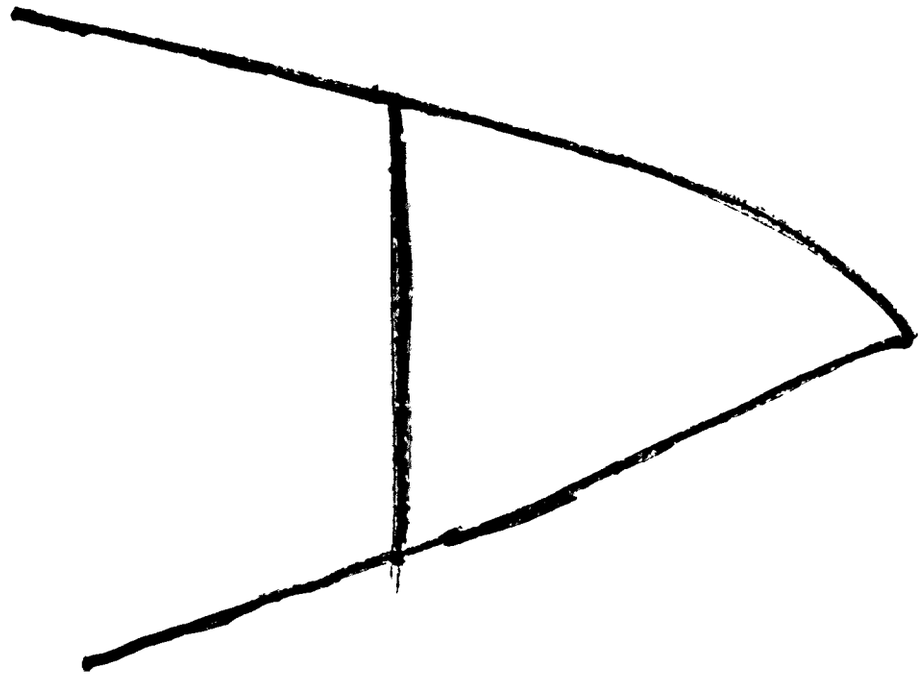
I am not aware of the manner in which Mr Scaldwell arrived at irrigable area. The irrigable area shown by Mr. Mackay consists of all assessed garden and wet land, whether occupied or waste, under each tank as shown in the Survey Registers.

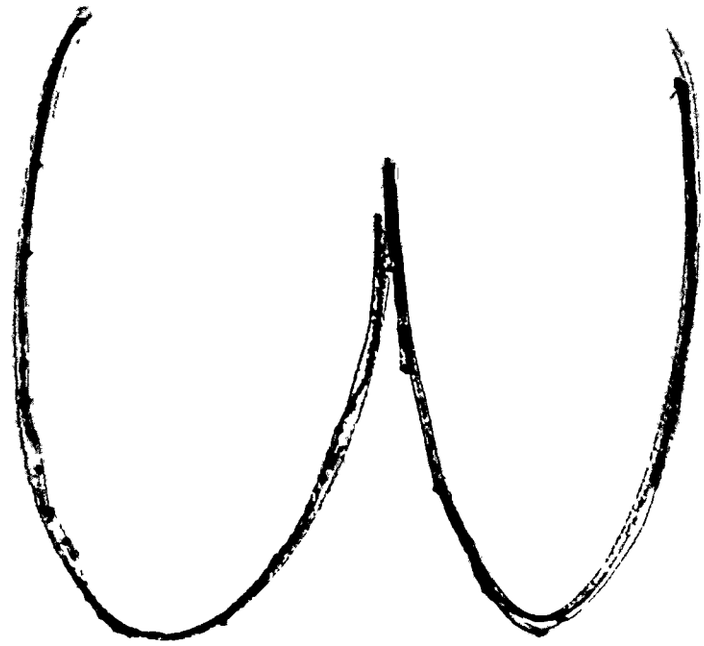
For all practical purposes I believe the amended Statement now submitted after careful scrutiny, to be correct.

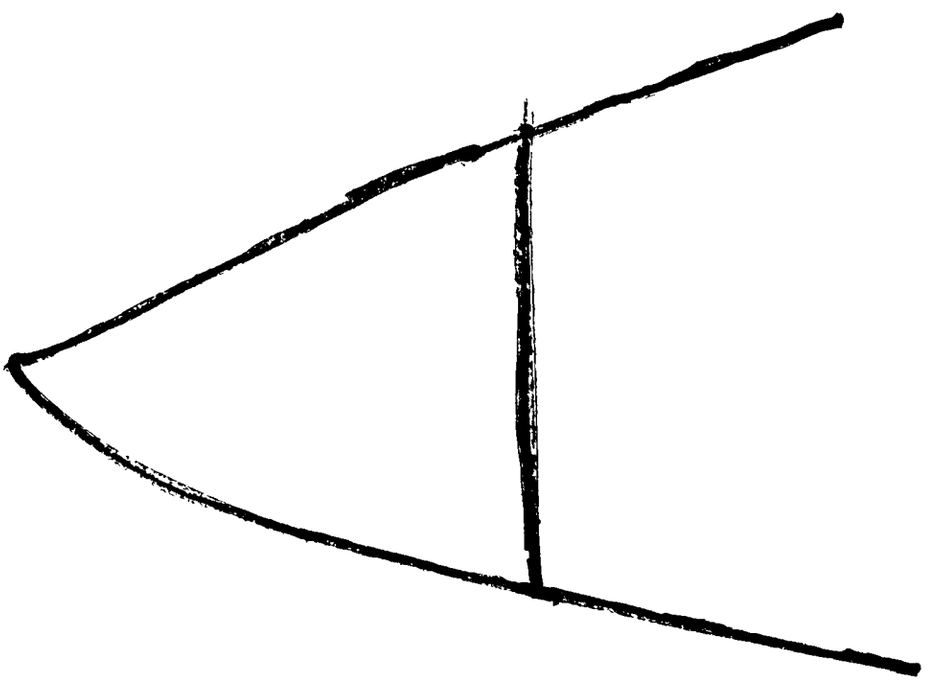
[signature]
Supt. Rev. Survey

No. 1043
26th April 1893.

To the Secretary to the
Govt. of Mysore
Q P IV







Camp No. 4

28 88

FROM Recd 1-92-1

THE RESIDENT IN MYSORE.

TO

The Dewan of Mysore

Camp, Ootacamund
Dated, ~~Bangalore,~~ 24th April 1893.

SIR,

With reference to major Ravenshaw's letter No 1197/28 88 dated the 8th instant I understand that there is no probability of receiving at a very early date your remarks on major Grant's report on the several schemes for a water supply. In submitting these remarks, when received, to the Government of India I should like to be in a position to them also of your views on an alternative proposal that has emanated by Government affecting the financial part of scheme.

2. If a joint scheme should prove practicable from the engineering point of view, the Government of India it probable that an arrangement for the supply of water to troops and Civil and Military station might be advantag made on lines similar to those which have proved successful

in the case of many Cantonments drawing their water supply from a neighbouring municipality. Applying the arrangement indicated to the case of Bangalore the Mysore Durbar would construct and manage the works entirely up to the service reservoir, the troops and the Civil and Military station drawing their water supply from this reservoir, paying for it by meter and making their own arrangements for distribution. This is an arrangement the Government of India consider very desirable.

I have the honor to be,
Sir,
your most obedient Servant,

J. Benson Colonel,
Resident.

MYSORE P. W. DEPT.

TO THE DEWAN OF MYSORE

for Information.

Herewith I submit 10 printed Copies each of Colonel Campbell's "Supplemental Report on the Hessenghatta water Supply Scheme", and "note on Major Grant's report on Bangalore Water Supply", as it may be advisable to send them on at once to the Resident. They will probably be sufficient to settle the question in favor of the Hessanghatta Scheme, and the more detailed notes on the report by Mr. Realdwell and myself, which I do not intend to print until after you have seen them, can follow when ready I expect Mr. Realdwells

report

report today, and will
send this on to you with
mine on Saturday or
Monday at latest.

[illegible]

Offg. Secretary
to the Government of Mysore
P. W. D.

Bangalore
5th May 93

Supplemental Report on the Hesseraghatta Water Supply Scheme

1. The Dewan in his note dated 18th February 1893, on the Preliminary reports on the Hesseraghatta Water Supply Scheme has proposed several modifications and these together with information lately received from England regarding pressure-pumps, renders it advisable to submit this supplemental report:—

2. Before entering into the details of the modifications it is earnestly requested that the question of the Supply as required by the Dewan vide his para 2 may be reconsidered with reference to the following remarks.—

Quantity of Supply.

3. It has been stated in the preliminary reports that from 1881 to 1891, the population of Bangalore increased at the rate of 15·72 but it is believed that these were years of great prosperity if the 10 years from 1871 to 1881 be taken the rate of increase will be found to have only been at the rate of 9·36, the average of the two periods

being taken the increase per 1,000 will be 125.4 in ten years, so that a population of 2,50,000 will not be reached for 25 years. The decade from 71 to 1881 was an exceptionally bad one owing to Famine, but in this Country there is no telling when the increase of population may not receive a check owing to famine, Epe-demics, or other Causes The Connection of the Mysore Railway System with East Coast railway may Cause a more rapid increase of population, but this is Problamatical and should not justify a large expenditure As regards the Supply per head it must be remembered that it is only required for domestic purposes, for watering roads and gardens Cleaning houses, washing Clothes &c, there will still be the Existing Sources available, Sankey's tank Dharmabady Tank, Miller's Tanks, Ulsoor Tanks, and others, Can all be utilized for ordinary purposes and even should these Sources run dry in Exceptionally bad seasons it will be

of

of little consequence as there would still be no scarcity of water for domestic purposes and moreover they are not likely to fail as soon as at present as they will not be drawn on so much. It is further believed that there are many Excellent wells in Bangalore, that have never been known to fail and these will supplement the supply for domestic purposes Taking all these circumstances into consideration, it is thought that a supply of 10 gallons a head is ample The subject of the supply required has been carefully considered for years by all the officers who have been Employed on the Bangalore Water Supply Schemes, and it has been generally decided that 12½ gallons per head for the Troops and 6¼ gallons per head for the native population is ample; this seems to be a very fair proportion, for, while all the troops are adults, a large proportion of the population are children

and

and it seems quite certain that if 10 gallons per head of the native population (including children) is not sufficient, 12½ gallons per head for the troops is far too little. When water has to be raised by pumping as at Bangalore, the question of the supply required, requires the gravest consideration, as every gallon raised not only adds to the Capital cost but also to the working Expenses, so that it is highly advisable that not more water than is actually required should be pumped up; if the supply were obtainable by gravity, the matter would not be of so much consequence. It cannot be too strongly recommended that the supply be limited to 10 gallons per head for 200,000 people. Supposing this supply to be given and the population to increase rapidly so that 250,000 is reached in only 15 years, the result will be that at the end of that time the supply will be 8 gallons per head

which

which is more than the 6½ gallons considered by many authorities to be ample By adopting the reduced scheme the saving on Capital cost would be 7 lacs (vide paras 15 & 18) and on working Expenses Rs 6,400 per annum, owing to a less horse power being required and consequently less fuel.

The latter sum capitalised at 4 percent represent Rs 1,60,000.

Continuous pumping

4. From para 11 of the Remarks note it is evident that he intends that pumping should be carried on for the whole 24 hours, Sundays included. This materially affects the cost of the project Whether it is advisable to pump continuously as a matter of economy, it is believed that it is often done in waterworks and there does not appear to be any objections; three establishments would be required instead of two to work the pumps in relief of 8 hours so that the extra cost of working would be about Rs 550 a year this capitalised at 4 percent, represents Rs 13,750 and there is no doubt that more than this will be saved

saved owing to reduction in size of pipes hence it is re-commended that pumping continuously be adopted.

5. In the preliminary report the level of the floor of the service reservoir at the Muntapam hill was fixed at 3055 but it has since been ascertained that this height is not sufficient to command the whole of Bangalore, it is therefore now decided to put the floor at 3075, this will be more satisfactory in every way for not only will it command the whole station but it will give a better head for the distribution while on the other hand the cost of pumping the extra 20 feet will be trifling. Level of Service Reservoir

6. Taking the supply required to be 12½ gallons for 250,000 people or 500,000 Cft. a day, the pipes (pumping 24 hours) will have to carry 347·2 Cft. a minute and the length of delivery main from Banawar to Muntapam hill being 37,000 ft. the discharge can be obtained with a 20" pipe having a head of 51' or allowing for bends and future incrustations and loss of head in service filters reservoirs say 70' the Delivery Main

velocity in the pipe will be 674' per minute.

The top of Banawar hill being 3097.64 and floor of service reservoir 3,075- it will be necessary to erect a stand pipe 48' high on that hill. By increasing the diameter of the main, the head may be reduced but the cost would be greatly increased and there can be no possible objection to the erection of a stand pipe of the moderate height of 48'.

In the preliminary report the diameter of delivery main was 24" and the cost Rs 7,25000, while with the 20" Cast iron main the cost will only be Rs 4,70,810 showing a saving of Rs 2,52,190 say 252000 so there can be no doubt about the economy of pumping continuously

Rising Main

7. The rising main need also only be 20" diameter, and the cost will be Rs 130,000 against Rs 170,000 giving a saving of Rs 40,000 The total saving on piping will therefore be Rs 2,92,000

Pumps and Engines

8. The height to which the pumps will have to lift

left the 347.2 cft a minute is 3075 + 70 + 11.68 friction head = 374.68 say 400'.

It has been ascertained lately that the cost of two triple Expansion Engines with Babcocks boilers each to lift 3858 gallons per minute to a head of 374 through 1¾ miles of 24" main will be Rs 353,000 or 176,000 each taking the rupee at 1/2 the H.P. required for each Engine would be about 524 the cost is therefore Rs 337 per H P

With Continuous pumping the Engines should be of about 300 H.P. each and the cost will be 1,01,100 or Rs 202,200 for two, to be safe it may be as well to allow 250,000. Exact information regarding the cost of these pumps will be obtained as soon as possible.

Savings

9. From what has been written it will be seen that by Continuous pumping there will be a Saving of Rs 290,000 on piping while the pumps and Engines will probably cost Rs 50,000 more than allowed in the preliminary report the total saving will therefore be 240,000.

10 The Dewan's Suggestions in para 25 that the front slope of reservoir should lie 2 or 3 to 1 and the top worth Suff. -cient to allow of raising hereafter another 3 or 4' materially increases the cost. The estimate has now been entirely revised with the following Construction details, front slope 2 to 1 top of bund 13' above weir, reaches to be 3' thick on a good back -ing of Jelly and Gravel and to be carried up to top of bund with a parapet wall 2½' high and 2' thick along its entire length, a toe wall to be allowed throughout top of bund to be 24' wide and Gravelled, rear slope 2 to 1 and turfed, a puddle wall to be provided throughout. These alterations together with increased rates that it has been thought desirable to allow as the work will have to be most carefully done. Lifting Cost of head works up to Rs 2,30,000 instead of Rs 1,48,000 showing an increase of Rs 82,000. The escape is of ample length but to allow for all possible

Contingencies

contingencies a long natural escape will be provided at the right of bund.

11. It is a matter for serious consideration whether it is safe with such a great length of delivery Channel to have a service reservoir to contain only 3 days supply, if a 7 days supply is provided for, the cost will be about 2,50,000, and it is thought that this will be money well spent, this gives an excess of Rs 1,28,000 on the former estimate. Service Reservoir

12. The filtering reservoir will probably cost Rs 50,000 instead of Rs 25000 provided. Filtering Reservoir

13. The stand pipe will cost Rs 10,000 and owing to increase of establishment the cost of Quarters for establishment may be taken at Rs 20,000 instead of Rs 16,000. Stand pipe

14. The other items will remain as before with the exception that it will be better to use Portland Cement for plastering inside delivery duct and cisterns and reservoirs, this will cause an excess of about Rs 8,000. Other items

15. The savings on pipes amount to Total cost of Project

to Rs 2,92,000 The Excesses are as follows

Pumps	50,000
Head works . . .	82,000
Service reservoir . .	1,28,000
Filtering reservoir .	16,000
Stand pipes . .	6,500
Quarters for Establishments .	4000
Other items	8,000
Total	2,94,000

Showing an excess of Rs 2,500, over the original amount of the project. Rs 3,00,000 may therefore be accepted as correct.

Steel pipes

16 Since the preliminary report was written, some information has been received from firms in England regarding steel pipes which seem to show that they are preferable to cast iron pipes in every way The advantages claimed are that as they require a much less thickness of metal than cast iron pipes they are much lighter and easier handled that they can be made in 24'0 lengths instead of 12'0 the usual length for cast iron pipes and consequently require fewer joints, and therefore there is less chance of leakage that they do not burst like cast iron pipes but can be easily repaired should they fail owing to excess pressure.

That

That while in cast iron pipes flaws in casting cannot be detected, in steel pipes, they can be seen during manufacture. Lastly, that they are cheaper. There are several different kinds of steel pipes made, the chief difference being between those welded and those rivetted, the former are rather more expensive and the latter possess the advantage of being made in greater lengths. Steel pipes being of Comparatively recent introduction, their life is not known for certain. They are coated with a bituminous composition to protect them from the action of air and water and some of them have been in use in South America for 20 years and are said to show no signs of deterioration. I am using in his treatise on Water Supply says that 25 or 30 towns had already adopted wrought iron pipes before 1861.

The

The piping required for Scheme is 26,862' pipes 20 diameter to withstand head of say 400 and 18,67. of pipes of same diameter to stand a head of 140' to the former pressure Steel pipes should be .250" thic and for the latter 128".
In working out the exact pressures on different portions of the piping, it is probable that the thickness of metal can be still reduced.
The Atlas Company give the prices of the thicker pipes, rivetted 25' long with Socket as 11/10 per ft and of the lesser thickness over at 7/10, so that the total cost of the piping required would be — .
26,862 × 11/10 + 18,678 × 7/10 =
464,144 Shillings = 23,207 £
and at Rupees 17 to 1 £
= 394,519
The weight of the ¼" pipes is 65.5 lbs per ft and of the ⅛" pipes 32.3 lbs. Consequently the total weight of piping would

would be 26,862 × 65·5 +
18,678 × 32·3 = 2,363,305 lbs
= 1,055 tons, Cost of freight
and Carriage to Bangalore
is Rs 30 per ton or 31,650 for
the whole piping. Consequent-
-ly the cost of the steel
pipes delivered in Bangalore
would be Rs 394,519 +
Rs 31,650 or Rs 426,169 and
if the same sum be allowed
for valves and laying
(length of pipes being
more than double it will
really be less) as was
allowed in the case of
cast iron pipes, the total
cost of delivery and
raising mains will be
Rs 4,80,109 or say Rs 4,80,000 —
— against Rupees 6,00,000
or a saving of Rupees 1,20,000.
If welded pipes are used,
the cost will be slightly
more. A further considerable
reduction can be made
on the cost by ordering
all the pipes required at
once, so that those of
different diameters can be

be together and a large saving in freight thereby affected, and it is believed that the total saving on the project by using steel pipes would not be less than $2\frac{1}{2}$ lacs bringing the estimate from 31 to $28\frac{1}{2}$ lacs.

The writer of this report has had no experience of steel pipes and it is believed they have not yet been used in India, but the advantages of using them in this country would be very great, when it is considered that the weight of 1 ft in length of a cast iron pipe 20" to bear a pressure of a head of 400' is 204 lbs and the weight of 1' of steel pipe of the same diameter and to bear the same pressure is only 65.5 lbs or 138.5 lbs less and as the freight is 2.6 pies per lbs, the saving in freights for 1' length is Rs 1-14-0.

Vi

The advantages of Steel over cast iron pipes are given in the following statement received from the Steel pipe Company.

	Cast iron	Mild Steel	Saving
Internal diameter inches	24	24	-
Length mile.	1	1	-
No. of pipes.	440	220	-
Weight of each pipe Cwt.	24·8	10·47	-
Weight of 1 mile tons	545·6	115·2	-
Relative cost per ton	1	4·25	-
" " of Carriage per ton.	1	1	-
" " on total .	1	·211	78%
" of laying per yard.	1	·7	30%
" number of joints..	1	·5	50%
" " height of lead each joint	1	·905	9½%
" " " Each mile..	1	·405	59½%
" Cost of making each joint	·1	08	20%
" " " of jointing one mile	·1	0·4	60%
" Total for one mile.	1	0·9	10%
" of pipes & Carriage.	1	0·84	16%
" Carriage & laying.	1	·834	16·6%
" Cost of pipes carriage, laying & jointing one mile	1	·788	21·2%

From this it is reckoned that in 33½ years the saving in cost between steel and cast iron pipes would amount at compound interest to a sum sufficient to renew the whole line of piping.

With reference to the proposal made by the Dewan in para 11 (2) a report by Mr. Scaldwell Executive Engineer is herewith enclosed from which it will be seen that there might be a possible saving of Rs 72,500 by having a Channel direct from Hesser-Ghatta towards Chickabettahalli Hill and pumping the water into a reservoir on the top of that Hill, but this saving will doubtless be more than counterbalanced by the increased cost of working Expenses caused by having to pump a greater height through a longer rising main, the advantages also of having the pumping station near the railing line as at Banawar hill are very great.

Reduced Supply with steel pipes

18. The saving that will be affected by giving the reduced supply of 10 gallons per head to 200000 people will be very great. A 16" steel pipe will be sufficient for rising and delivery main and the H.P. of the engine required will only be 200 instead of 300; there will also be saving on other items. The calculations have been worked out and the total amount of the estimate is Rs 24 lacs.

In the preliminary report it was mentioned that no attempt had been made to work out the cost of distribution in detail, the figures entered in that report were calculated from those given by officers who had been employed on investigating the Water Supply. It is certain that owing to the scattered nature of the Cantonment the cost of distribution to that part of Bangalore will be far greater per head than the cost of distribution to the pettah; Consequently to lump the cost of the two and divide the sum to be paid by each Municipality in the proportion of the population would not be fair. It is therefore strongly recommended that the Scheme should be a joint one only as far as including the Service Reservoir and the cost of the distribution be worked out separately by each Municipality.

Working Expenses

10. In the preliminary report Cost of fuel &c. was entered at Rs 20,000, this was

was on the assumption that wood would be got for the actual cost of growing it; if the market value of fuel is to be paid the amount allowed will have to be increased very considerably. The H.P. of the Engine required is 300 and at least 5½ lbs of wood will be used per H.P. per hour, this amount to 17.7 tons per day, and at the lowest market rate 6/4 per ton would cost Rs 40,378 a year, to this should be added 16 percent for oil waste and wringing the total up to Rs 47,000.

It has been ascertained from the Forest Department that the actual cost of growing Casuarina firewood is Rs 1-0-5 per ton, the cost of sawing into billets is Re1, and if the plantations are near the pumping station, carriage may be taken at Nil bringing total cost of fuel to say 2½ per ton. In that case, the cost of fuel per annum for the

300 H.P. Engine would be Rs 16,150 and for oil waste Rs 3950 total Rs 20,000.

As Casuarina trees take between 10 & 15 years to reach maturity, it cannot be too strongly recommended that planting trees close to the pumping Station should be put in hand at once. With reduced scheme cost of fuel would amount to Rs 13,600.

21. In the Preliminary report para 43, the analysis of the Hessaraghatta Tank as made by the Chemical Examiner Mysore, was given and his opinion that the water was a good potable one was quoted. Since then Major Grant R.E. sent some of the Water from the same tank to the Chemical Examiner Madras, and the result of his analysis are as follows:- Quality of Water.

Total Solid Grains per litre	250
Volatile do do	090
Chlorine " "	028
Total Hardness Clarke's Scale	5.600
Permanent do	1.050
Free Ammonia in Grains per litre	.120
Albumanoid ammonia do	320
Nitric acid do	300

and

and his remarks are "
quality of the water as
inferred from the results
obtained on Examination Sus-
-picious." As some persons
may attach undue im-
-portance to this remark
it is necessary to enter in
considerable length into the
question of waters analyses
and the purity of waters

22. It will be noticed that
there is considerable difference
between the analysis of the
Chemical Examiner Madras
and that of the Same Official
in Mysore, and while the
Latter says the water is a
good potable one, the former
says it is Suspicious. It is
quite possible that both
officers are correct as it is
well known that tank waters
varies at different periods
of the year; in fact two
Samples of water taken at
the Same time from the Same
part of the Same tank have
been found to vary Con-
-siderably. Vide Colonel
Mullins Report on the
Bangalore water Supply,
the analysis of a bottle

of water taken from a tank would by no means represent the average quality of the water throughout the tank all the year round.

23. Assuming that any value is to be attached to the Chemical analysis of water as regards its wholesomeness (which later on will be shewn not to be the case) and taking the Madras analysis of the water it will be found that it compares favorably with other Bangalore Waters that have been pronounced usable the only impurity in Excess over one other Sample being Albumanoid ammonia. and this is not known to be injurious to health, in fact, water containing ·80 Milgrams per litre of albumanoid ammonia was declared by the Sanitary Commissioner Madras to be not injurious to health in his letter No. 96 dated 31st January 1884, and Dr. M. F. Anderson a great authority on the Subject stated in a letter to the "Sanitary Record"

that

that "he had never been able to obtain Conclusive evidence that the dangerous elements of bad water are evolved as albuminoid ammonia."

24. That the water compares favorably with others declared by the Chemical Examiner to be usable is shewn by the following table

	Dhobies Well Water	Balsur Tank Water	Agaram Tank Water	Hessenghatta Water
Total Solids Grains per litre	·25	·31	·25	·25
Volatile Solids — do —	·07	·08	·10	·090
Chlorine — do —	·042	·089	·043	·028
Total Hardness Clark's Scale	2·45	3·5	4 2	5 600
Permanent — do — do —	1·75	1·75	1·75	1·050
Free ammonia Milgrains per litre	·24	·48	·12	·120
Albuminoid — do —	·4	·48	·16	·320
Nitric Acid — do —	2·4	2 4	3 0	·300

It will be seen that the Hessenghatta water is superior to all the others except as regards hardness and when they were classed as "usable" it is not clear why the Madras Chemical Examiner classed the Hessenghatta water as suspicious" the only objection is that it is a trifle

trifle hard but the Chemical Examiner Mysore states that "the total hardness is nothing like sufficient to render it unfit in any way for drinking purposes."

25. The analyses of the Madras Chemical Examiner is in such a form that it is somewhat difficult to compare it in detail with the analyses of water made in England, but a general comparison may be made. Put into English measure, the analysis of the Hessenghatta water is,

Total Solids Gemms per gallon	17.51
Volatile — do —	6.3
Chlorine — do —	1 96
Total Hardness Clark's Scale	5".6
Permanent — do —	1° 05
Free ammonia gemms per gallon	.008
Albumanoid ammonia — do —	.0218
Nitric acid — do —	.0204

From Nevil's treatise on Hydraulics the following information is taken. Number of Gemms of Solid matter contained in one gallon of the following water

Names

	Grains
Thames at Greenwich ...	27.9
— " — London ...	28.0
— " — Westminster ..	24.4
— " — Twickenham ...	22 4
— " — Teddington	17.4
New rivers (London) .	19 2
Lee	23.7

From this it appears that the Kissing hatta waters is better than all these.

The following is taken from Fanning's treatise on Water Supply.

	Solids grains per U.S gallon	Hardness by Clark's scale	Remarks
Thames, rivers above London	20.19	14.5	U.S Gallon = $\frac{231}{277.25}$ Engls gallon.
New rivers London	16.496	14 9	
Kissing hatta Water Supply	29.678	9.8	

From this has been said to show that even if the Chemical Analysis is to be regarded as of any value, the water is quite fit for drinking purposes and is far superior to many others used for that purpose.

26. At a meeting held at the Institute of Civil Engineers on 24th January 1882, the subject of the analysis of

of potable waters was dis-
-cussed by many of the
most eminent authorities,
and it was generally
decided that neither
Chemical nor Microscopic
analysis could enable
it to be ascertained
whether water was wholesome
or not. It will be well to
quote some of the opinions
given.
Mr. C. W Folkard A.R.S.M
says "Having briefly re-
-viewed the advantages
and defects of the various
processes of estimating the
nature and amount of the
organic Contaminations of
potable waters, it seems
impossible to come to
any other Conclusion than
that the subject is as yet
beyond the scope of analyti-
-cal Chemistry", and again
"The present methods of water
analyses are quite Capable
of showing if Contamination
has taken place at all events
in the majority of Cases,
but whether that Contamination
is injurious to health or not,
there

there is no knowledge by
Baldwin Latham, one of the
greatest authorities on
Sanitary Engineering says
"The impure waters of the
Thames was not always
unwholesome waters, nor
was the pure waters of the
Thames always pure" again,
"at present if Engineers were
to take the dictum of some
Chemists, it was quite clear
that there was no water supply
fit for use". The following
quotation taken from the
same authority shows how
absolutely useless Chemical
analysis is as a means of testing
the wholesomeness of water
"The highest annual death
rate and the highest zymo-
tic death rate in London
(1871) occurred when the
impurities in the Thames
and Lee were below the
average, and the waters of
the deep wells were freest
from impurities The high
fever death rate in 1860 —
occurred when the impurities
in all the sources of water
supply were below the average
The lowest death rate in
London

London occurred in 1872
when the impurities in the
Thames and Lee were above
the average, and in 1880
when the death rate was
low, all the Sources of
water Supply Contained
impurities in Excess. The
Zymotic death rate of
London was lowest in
1879, when all the Sources
of water Supply Contained
impurities above the average,
and under Similar Circum-
stances the Zymotic death
rate was lowest in 1880.
In the year 1870 the waters
of the Thames and Lee
Contained the least amount
of Impurity yet in that
year the death rate was
above the average. In the
last three years there had
been an Excess of impurity
in all the Sources of water-
Supply, yet during the
Same period the death
rate had steadily declined".
Doctor Thudichum stated
"The Analysis of waters with
reference

reference to the quantity of organic matter contained in it was hygienically speaking of no value," and again "microscopic art was just as impotent as Chemical art to determine whether water was wholesome or not." Mr. Charles Ekin states as follows. "Professor Huxley pronounced an emphatic opinion that water might be as pure as possible from a Chemist's point of view and yet be most deadly", again "Mr Ekin quite agreed with the Author and Dr. Thudichum as to the little value to be attached to the determination of organic matter in water, because he had over and over again examined waters that had undoubtedly given rise to typhoid fever, and found that it contained a very small amount of organic matter and he had gone into Districts where there could be

Le he no sort of Contamina-
-tion and Examined the
Springs, rivers and
brooks in which he had
frequently found large
amounts of organic —
matter that by no test
could be distinguished
from the organic matter
in Sewage."

27. It having been proved
without doubt that
Chemical analysis is no
test of the wholesomeness
of waters, the question arises
as to how the gathering
ground for a water supply
is to be selected, and the
common sense answer
appears to be, that of
the people who have
been for years in the
habit of drinking the
waters from that Catchment
are healthy, it will
be a fit source of Supply.
Of course, having two
Catchments, one cultiva-
-ted and populated and
another just the reverse,
both of which answer
every

every requirement of
supply; no Engineer in his
senses would select the
former, but supposing
that the former satisfied
all conditions as to supply
cost &c, it would be
cheerfully to reject it
simply because a Chemist
stated that the water
was suspicious, when no
evils had resulted to
the people who had been
drinking it for years.
It has been shown that
the Sewage Contamination
in the Thames does not
affect the health of
London, which is one of
the healthiest Cities
in the world. What harm
then can possibly result
from the Sewage of the
700 persons residing on
the Messerghatta Catchment
of 7 Square miles. In the
former Case the population
is about 400 to the Square
mile and the Sewage
is discharged direct into
the

the river, while in the
latter the population
is 100 to the Square mile
and the Sewage is more
or less purified by
earth before the water
reaches the tank

28. It has been mentioned
in the preliminary report,
that the land in the
Catchment of Nessarghatta
Tank is little if at all
manured, but supposing
that manure is used,
it is composed Chiefly
of Cowdung with a little
straw and ashes. Now,
unless it is proposed
to fence in the whole of
the Catchment, and not
allow Cattle on it, the
Chief ingredient would
still be deposited on the
ground, the only difference
being that when used as
manure it is worked into
the Soil and thereby puri-
fied, while in the other
Case, the rainfall runs
directly over it into the
tank.

As regards decayed vegeta-
-tions, it must be admitted
that it is hardly possible
to obtain a catchment with-
-out vegetation of any sort
on it, either scrub jungle
or grass, and it is thought,
that as regards harmless-
-ness, the balance is in
favor of decayed edible
crops.

29. In the course of the
debate at the Civil Engineers'
Institute, Mr. Baldwin Latham
stated that "he believed
he should be able to show
that certain meteorological
conditions were connected
with every one of these
epidemics which come
into operation only at a
particular time." The —
writer of this report is
of opinion that, that is
undoubtedly the case, and it
is believed that in certain
conditions of the atmosphere
certain disease germs are
generated and affect more
or less those predisposed,
it is more than probable

that these germs impregnate the water as well as the air, in which case, the careful selection of a gathering ground, and any amount of filtration would be of no use.
If this theory be correct, it follows that the water in a reservoir situated in a locality where the germs of malarious fever were plentiful, would be unwholesome, and it would be quite possible to have a typical Catchment of bare rocks and yet obtain water from it containing the germs of fever. Such water would no doubt be pure from a Chemical point of view The Valley of the Arkawatty River is healthy, and it is believed there is no special form of disease prevalent.
30. The Conclusions arrived at are:—
1st. That it is preferable

to use water that Experience has shown to be wholesome even if the Chemical analysis gives bad results, rather than to use water known to be unwholesome should the Chemist declare it to be pure.

2nd. That in the Case of the Bangalore water Supply, the valley of the Arkavathy being healthy and the health of the people using the tank water in the valley being normal, it would be folly to C the Hessaraghatta scheme merely because a C says the water is Susp but if another Scheme be proposed with equ advantages as regards quantity of Supply, Cost and the Chemical Examinati of the water shows it to contain less impurities, then by all means adopt it if it can be proved, that the water is wholesome as well as Chemically pure.

[signature] Lieut Col R.E.

Bangalore
22nd March 193 Chs

Secretary to the Government of Mysore. P.W.D.

MYSORE P. W. DEPT.

TO THE DEWAN OF MYSORE

for Information.

I forward for your information 25 Copies of my note on Major Grants Report on the Bangalore Water Supply & Projects.—

2.— I have considered it advisable to answer the arguments brought forward in Major Grants report, item by item for facility of reference although this necessitates considerable repetition.—

3.— I need hardly say that with my current work I have had little time to devote to the wording of my note, and that if I had the time I should be able to adduce more forcible reasons to show that

Scheme is the cheapest as well as the best project to adopt for a Joint Water Supply Scheme for Bangalore.—

4.— I again personally visited the Hesaraghatta Valley lately and was much impressed by the numerous favorable sites to be obtained for Reservoirs, not so much that secure foundations could not be obtained, although at considerable expense, but because the capacities of the Reservoirs are so small that several would have to be constructed even for a Scheme for the Pettah alone.—

5.— The result of my inspection has led me to believe that even for the supply of our Pettah it would be cheaper to adopt a modified Hesaraghatta

Project

Project than the Maligal.
I am also sending Mr. Scaldwell's note on Major Grant's Report, together with other old reports which you may wish to refer to. ——.

W. D. W. Hutchins

Offg: Secretary to the G. of Mysore P. W. Dep

Bangalore
13th May 1930

Note on Major Grant's report on Bangalore Water-supply.

1. I have only just received Major Grant's report, dated 23rd March, on the Bangalore Water-supply, and, as I leave for England on the 5th, I shall not be able to reply so fully as I should wish.

2. Major Grant has thought it necessary to criticize the Hessarghatta Scheme in detail, though, perhaps, it would have been better if he had simply sent in his report, and allowed others to decide on the respective merits of the two projects.

3. It is much to be regretted that I had not an opportunity of seeing Generals Sandford and Lovett when they were in Bangalore, and to whom Major Grant communicated his views about the several schemes, as they would then have heard both sides of the question; this is more to be regretted now that I find I have only three days in which to reply to Major Grant's report of 50 pages.

4. Major Grant's arguments are exceedingly plausible and very well expressed, so much so in fact that, on first reading over his report, I was almost led against my own conviction to believe that in the Maligal Scheme we had at last found the only real solution of the difficulty of the water-supply to Bangalore, and that the Hessarghatta Scheme was an altogether preposterous one, had been underestimated, and prepared on wrong data; but, on going more carefully into his report, I find that many of his arguments are unsound and very much one-sided.

5. There can be no doubt that the Maligal valley water is chemically purer than that of the Hessarghatta Catchment, though experience has showed that the latter is wholesome, and quite fit for drinking purposes. The question of what scheme is to be adopted rests entirely on the supply available, and, notwithstanding all that Major Grant has said on the subject, I am still convinced that the Maligal valley will not give a sufficient supply for the whole of Bangalore in a year of deficient rain-fall. This opinion is shared by all Officers who have had long experience of the locality, and in a letter I had lately from Mr. deWinton, whose opinion Major Grant quotes freely, he stated that the Maligal Catchment was excellent as regards quality of water, but about the quantity he was more doubtful. We have had bitter experience of over-estimating the run-off in the cases of the Sankey's Tank, and the Kukarhalli Reservoir at Mysore, and it would indeed be a calamity if, after spending 30 lakhs or so on the Maligal Scheme, it were found that Bangalore still suffered from a succession of water famines, far better would it be to spend 100 lakhs to obtain a certain supply.

6. In Major Grant's original report on the Maligal project, dated 25th April 1892, he assumed the run-off from the Maligal Catchment at 13 per cent in a bad year of 17″ rain-fall, 25 per cent in an average year of 35″ fall, and 40 per cent in a good year of 56″, and he calculated that with this run-off a sufficient supply would be obtained for 3 years for—

		Gals.	Gallons.
6,000 Europeans		$12\frac{1}{2}$ =	75 000
95,000 Natives		$6\frac{1}{4}$ =	593,750
	Total Gallons...		668,750

or 107,000 c. ft. per day! As that run-off would not give nearly enough water for 200.000 people at 10 gallons per head, it was necessary for Major Grant either to abandon the scheme, or increase the run-off, and he preferred the latter course, believing that he was justified in doing so by the fact that the Maligal Catchment was steeper than that at Nagpur, where the run-off was found to be 19·5 per cent, for a rain-fall of 20″. Major Grant therefore assumes that the run-off will be

25 per cent in a year of 16·5″ rain-fall against his assumption in his previous report that the run-off would be 13 per cent with a fall of 17″; allowing that any comparison can be made between the Maligal and Nagpur run-offs, it seems exceedingly rash to allow a run-off of 25 per cent at Maligal with 16·5″ rain-fall, while experience has proved that at Nagpur with a rain-fall of 20″ the run-off is only 19·5″ per cent, and I am firmly convinced that with a rain-fall of 17″ evenly distributed throughout the year, the run-off at the Maligal Catchment will not exceed 13 per cent.

7. Major Grant also allows considerably less loss from evaporation and percolation than he did in his former report, the amount now entered being 16 and 10 millions c. ft. respectively against 26½ and 22 millions c. ft. Practical experience in this Province has shown that the amount of evaporation he allows is too little, and I also consider that his reasons for reducing the amount of percolation are not sound.

8. Notwithstanding the extremely favourable view of the run-off, evaporation, and percolation Major Grant expresses doubts in several parts of his report regarding the sufficiency of supply: he states in para 8, however, that the aim should be, "not so much to carry out at once a complete scheme as to adopt one which will "be capable of extension!" Supposing this reasoning to be sound, it is surely advisable that the expenditure that may have to be incurred should be known. There can be little doubt but that the supply in the Maligal valley will be insufficient, and the Water-supply project should include the cost of extending the Catchment; to expend 30 lakhs now on a work, knowing that almost to a certainty a large sum would still have to be spent, without including the latter in the total cost, and in all calculations regarding working expenses, water rates, &c., would be sheer folly.

9. In para 87, Major Grant says that in the Hessarghatta proposals an entirely new departure is taken, and it is assumed that an area sufficient of itself cannot be obtained, and that indent must be made on a long chain of tanks lying outside of it to supplement the deficiency. In my opinion the system adopted was perfectly correct, the least possible amount of run-off was taken, and the area required to gain the desired supply was calculated, this appears to me to be much safer a method than that adopted by Major Grant, who arbitrarily selects a catchment of a certain extent and then *assumes* a run-off sufficient to give the required supply.

10. In the latter part of Major Grant's para 87 he seems to complain that the run-off in the Hessarghatta Catchment has been taken at too low a figure, surely if this is an error, it is one on the right side The prospects of a run-off are not exceptionally bad, no worse than at Hebbal or Rachenhalli: but as the run-off at Sankey's Catchment has reached so low a figure as 8 per cent, it was thought prudent to assume that such a low run-off was possible at Hessarghatta. The fact that the run-off from the Kakol Tank was 11 million c. ft. in a year with rain-fall below the average is beside the question, as the rain-fall was considerably more than 17″; moreover Major Grant seems to forget that the run-off depends on the character of the rain-fall. In some years with 17″ fall the run-off might be 20 per cent and in another only 8, and in the Hessarghatta Scheme, I purposely took the worst view of the case, so as to show that there was no chance of a failure, and I think it a pity that Major Grant did not do the same as regards the Maligal Scheme, and adhere to the figures given in his first report.

11. Major Grant, with what object is not apparent, argues that there is no advantage in having so large a catchment as 211 square miles, but I am not aware that any one said that there was, and it will probably be many years before more than 50 square miles are required, and this can be got not only without any engineering difficulty but without any engineering work at all.

12. Para 83 of Major Grant's report is rather puzzling; he intends apparently to give a supply of 10 gallons a head for 200,000 people, and his storage arrangements, &c., are framed on that basis, but he allows piping large enough to give a supply of 12½ gallons per head to 250,000 persons, should the demand ever

each that amount. He seems to forget that when that amount is required, more powerful pumps will be wanted, and larger service reservoirs, settling tanks, and filtering beds, required, so that the "Extensive dislocation of the scheme" which he is so anxious to avoid will take place. The object in having the pipes larger than necessary is not apparent to me.

13. Considering the supply from the Maligal valley to be doubtful, Major Grant shows how the catchment can be increased by 12 square miles at a cost of about 2½ lakhs; I regret I have not time to go into the details of the proposals, and will only remark that the principle seems utterly incorrect. In order to get an increased catchment of 3 square miles, Major Grant makes a small channel 5 feet wide to a tank having a catchment of 3 square miles. This will of course only draw off the water in the tank itself. During any heavy rain-fall the surplus will go to waste as at present, and it is altogether incorrect to call this increasing the catchment by 3 square miles; to do so would require a very large channel. Major Grant also seems to forget that he would have to buy the tanks he taps, and also pay compensation for the crops, and that the loss of revenue would go to swell the annual expenses; another point is, that the extra 12 square miles is partly cultivated and Major Grant seems to make a point of this as one of the objections to Hessarghatta. I believe that Major Grant has under-estimated the cost of these extensions, and they will amount to at least 7 lakhs excluding compensation.

14. Taking the run-off from Maligal as 13 per cent in a bad year, and of the extra 12 miles of the catchment as 8 per cent, (as allowed at Hessarghatta) the supply would be 51·4 37·8=88·8 millions c. ft., while in the case of the Hessarghatta it is 95·79 millions c. ft. It may safely be stated that to get the increase of 12 square miles, that is by making channels sufficiently large to carry off all the available rain-fall, or to construct tanks sufficiently large to impound all the available run-off assumed, the cost including compensation would be not less than 15 lakhs, and the result would be that the supply would not be so much as that at Hessarghatta and that the quality of the water little if any better.

15. In para 82 Major Grant states that the rain-fall of 15th and 16th March sufficed for a stream of water between 4 and 6' feet deep to pour over the reef of trap rock in the bed of the Maligal stream at Nagarbhavi. This in my opinion does not prove anything. in the first place the stream was not gauged, nor was the duration of flow ascertained. The rain-fall on these days was of cyclonic character, and the fact remains that owing to its geographical position the Maligal valley gets very little of the north-east monsoon during which usually the tank filling rains of this Province occur.

16. Major Grant makes much capital out of the superior quality of the Maligal water to that of the Hessarghatta as shown by the Chemical analysis. I have already treated this subject at considerable length in my supplemental report, so it will be unnecessary for me to say more here.

17. Major Grant has used every conceivable argument, repeated in several parts of his report, to try and prove that the Maligal Scheme is far superior to the Hessarghatta, but the fact still remains that, as he himself admits, the quantity of supply from the former catchment is doubtful, while from the latter it is certain; nothing that he has said alters this. Even by adopting an unusual amount of run-off not justified by experience, and deducting an unusual small allowance for evaporation and percolation, the quantity of supply is as admitted by himself, doubtful; that the cost of adding 12 square miles of drainage will be only 2½ lakhs. I believe to be quite inaccurate, though he may add the water from a few tanks for this sum. If all the rain-fall available from these 12 square miles is caught and brought into the Maligal reservoirs, the cost will be enormous and the result will be, that even then the supply will not be equal to that at Hessarghatta I say therefore that it would be better to spend 50 lakhs on a scheme like Hessarghatta with a certain supply, than 5 lakhs on an uncertain scheme such as the Maligal, even supposing it could be carried out for that sum.

18. The revival of the Rachenhalli Scheme and [illegible] favourably with the Hessarghatta has been sprung on me like a mine, and as I am not acquainted

with that catchment, and have now no time to look up records on the subject, I will leave my "locum tenens" Mr. McHutchin to reply to that part of Major Grant's report. Mr. McHutchin being intimately acquainted with the nature of nearly all the catchments in the Province during a period of 20 years is well qualified to give an opinion. There can be little doubt but that the Rachenhalli Catchment is much more highly cultivated and is more thickly populated than the Hessarghatta, and that the tanks are much more valuable, and consequently more compensation would have to be paid, and the loss of the revenue would be greater. I also do not believe that the extra catchment can be obtained with the ease indicated by Major Grant, whose ideas of the methods by which catchments can be increased seem to be quite erroneous.

19. Major Grant having criticized the Hessarghatta Scheme in great detail it is necessary for me to reply to these criticisms at some length. I am very sorry to have to do this, but it is obviously incumbent on me to do so to prevent the readers of his report receiving incorrect impressions. As many of Major Grant's arguments and statements are repeated in different words in several paras, I will refer to all these as G1, G2, &c.

20. *Paras G8 (3rd) and G54.*—I say that a scheme, which is estimated to cost a certain sum, on which sum all the calculations as regards working expenses, water-rates, &c., is based; and which scheme does not afford the required supply without a heavy additional outlay, *is* a failure; and this would undoubtedly be the case with the Maligal Scheme, though, if the additional expenditure is taken into account in the first instance, the case is different. It would not be a sound excuse in private life to begin so economically that the necessities of existence could not be supported.

21. *Para G10.*—The rain-fall table given in Mr. Scaldwell's report is quoted; this is hardly fair criticism, as both that officer and myself have stated that those tables are incomplete and untrustworthy; a glance at the figures will show this to be the case, and it is a pity they were published. It is mentioned in this, and in many other paras, that the catchment area of the Rachenhalli valley can be increased to 50 square miles without encountering any engineering difficulties (the cost of obtaining this increase is nowhere stated), but in the Hessarghatta Scheme the catchment can be increased without any engineering work at all. There is considerable difference in increasing a catchment by adding drainage areas in the same valley, to increasing it by adding drainage areas from other valleys.

The quotation given at the end of this para does not seem to have much point, the Pennakini and the Arkavati are just as much rivers as the Maligal will be when the four lakes are constructed.

Major Grant's idea that within the next half century mills and manufactories may be started in the Hessarghatta valley is rather far-fetched, and as human agency, in the shape of the Mysore Darbar, can prevent such works being erected, it would be safer, as an argument against the Maligal Scheme, to say "who can positively assert that, within the same half century, there will not be an earthquake that will shatter the masonry dam at Nagarbhavi?"

22. *Para G* (41).—The principle adopted in the Hessarghatta Scheme is not the same as that adopted in the Rachenhalli: in the former the tanks to be brought up are all in the same series, in the latter they are not if over 36 square miles should be ever required, and Major Grant who has had some experience of tanks should know that this makes a considerable difference.

23. Major Grant gives as an example of why such a large catchment is not required, because Sankey's, Miller's, and Ulsur tanks were sufficient this year, but he forgot that the rain-fall this year was 24″ inches and not 17″, moreover the supply would fail before June, or what is the use of the temporary water-supply scheme? Major Grant in his estimate for earthern dams does not seem to have made any arrangements for the disposal of water, during construction. This will be by no means an easy matter if the run-off is so great as he states.

24. From a conversation I had with Major Grant last night, I gather that when he increases his catchment he intends turning the tanks into impounding reservoirs. Now supposing on the 21 square miles of extra catchment at Rachenhalli there are 6 tanks, he will have to make them all impounding reservoirs at considerable expense, or else he will have to treat the tail work as it is proposed to treat Hessarghatta at a cost of probably 2½ lakhs. The objections to having such a large number of impounding reservoirs are obvious.

25. It does not at all follow that a scheme based on a tank 4 miles distant from the site of the proposed service reservoir ought to be very much less costly than another based on a tank 11 miles from the same objective. If, as Major Grant says, "other things were equal," such would be the case, but other things are not equal, as the cost of constructing the reservoir, connecting channels, value of tanks, compensation, loss of Revenue, will be much greater in one case than in the other; however as I have before said, I will leave this matter to be worked out by Mr. McHutchin, as I have no time to go into the details.

26. In his para (41), as well as in many others, Major Grant makes comparisons between the Hessarghatta specification and data and those of other projects, and I contend that this is absolutely and utterly absurd. As regards specifications, cannot two works be built, both of which answer the purpose required, one cheap, and the other expensive? Because Mr. DeWinton allowed a new bund for his Rachenhalli Reservoir is that any reason why I should allow a new bund for the Hessarghatta Reservoir when circumstances are quite different, the existing bund being strong, 50 feet top width in most places? Because Mr. DeWinton built his service reservoir above ground is it necessary that I should do so, when I consider it better and cheaper to form it in cutting? Because Mr. DeWinton pointed his revetment with portland cement, is it necessary that I should do so, when I consider it contrary to sound engineering principles, and so on?

As regards data, Major Grant must know that rates depend chiefly on lead and lift, and that two precisely similar works might be constructed at different sites one costing double that of the other! The hard red murum of clayey nature, specified by Mr. DeWinton as to be used for his bank, may have had to be got from some distance, while that soil can be got close at Hessarghatta. I cannot think of anything more absurd than comparing specifications and rates in the manner Major Grant has done in order thereby apparently to raise the cost of the Hessarghatta Scheme to 50 lakhs. If I were to adopt the same course I might say that as Major Grant only makes the top of his earthen dam in the Mahigal valley 5′ above water-level, a great saving could be effected in the Hessarghatta bund by adopting his specification, as I have considered it necessary to allow top of bund 13′ above F. S. L., or 8′ more.

27. As regards the details mentioned by Major Grant in his para 41 II, (*a*), Fanning, one of the greatest authorities on water-supply, gives the limiting velocity in a 24″ pipe at 5·3 a second and in a 20″ pipe at 5′. The velocity allowed in the Hessarghatta Scheme is 3·2 a second, but supposing this ·2′ a second extra velocity to be not advisable in the pumping main, all that will be necessary is to increase the diameter of the pipes from 20″ to 22″ for a length of 1¼ miles. There is absolutely no reason why the delivery mains should be more than 20″ diameter, a pipe of this size will discharge 450′ a minute with a velocity of 3·438′ a second, the limiting velocity given by Fanning being 4·7. If continuous pumping is allowed, the size of the pipe need only be 18″; of course a 24″ pipe would require less head and velocity would be less, but a 30″ pipe would be still better in that respect, and so on; the question is, if a 20″ pipe gives the required discharge with available head and with a velocity well below the maximum, is it advisable to lay down a 24″ pipe, the difference in cost being Rs. 3,20,000? If Major Grant's method of providing for a further increase is to be adopted, all that will be necessary is to increase the height of the stand pipe by adding 37′ to the height of the latter. The 20″ pipe would then discharge 550 cubic feet a minute with a velocity of 4·2 feet a second which is still below the maximum; of course in this case pumps powerful enough to raise the water this extra height would have to be provided in the first instance.

(*b*). There is no reason why the pumping should not go on for 13½ hours, and after due consideration I have concluded that great saving will be effected by pumping 24 hours.

(*c*). The floor of the service reservoir was placed at 3,055·00, as that level will command the whole of the station within a distance of one furlong from any house, but I have since thought it better to put the level at 3,075·00.

(*d*). It was stated in my preliminary report that no attempt had been made to work out the cost of distribution, the figure given by others was adopted, that is Rs. 3½ per head ; it was known that the supply to be carried was double, but the extra cost owing to the increase in the size of pipes it was considered would be counterbalanced by the less length required for the petta which is more compact.

28. *Para* 43.—The assertion made by Major Grant that, " it is a well known " fact that a mass of water in quick motion exercises a very purifying effect," is not quite correct, as it will be seen from the discussion at a meeting at the institute of Civil Engineers, on the 24th January 1882, that the opinion of most authorities on the subject was against that theory.

29. Is it not more probable that Manchester and Liverpool are getting their supply from lakes in Cumberland because it is as cheap, or cheaper, to get it thus by gravitation, than getting it from rivers near by pumping? The question of the London Water-supply has been engaging earnest attention at Home, not only now but for years, and, as the demand is increasing, it has been proposed that the supply should be got from the highlands of Wales, or from the Cumberland Lakes, because, if the cost of supplying water from these sources is no greater than at present, it would be better to get a chemically purer supply.

30. *Para G* 47.—The information received from Nagpur that 19·5 per cent of the rain-fall of 20″ flows off the catchment area certainly does not justify Major Grant in assuming that 25 per cent of rain-fall of 16·5″ will flow off at the Maligal valley, even though the catchment is 25 per cent steeper.

31. *Para G* 56.—As already stated Major Grant's methods of increasing his catchment are not correct, he makes a channel 5′ wide to carry the drainage not only of 3 square miles belonging to the Tanniranhalli (Mattikere) tank, but also of an extra 3 square miles in another catchment, *vide* para 57. After seeing the size necessary for the catchment channels of the Sankey's tank, it is surprising how Major Grant has considered that a channel 5′ wide will be sufficient to take the discharge from an area of 6 square miles. If Major Grant intends to increase the capacity of the Tanniranhalli tank so that it will store all the water run-off the 6 square miles, and then run it gradually along his 5′ channel into the Maligal Reservoir, then that amounts to having a 5th impounding reservoir, and it will be necessary to make that reservoir safe, and perhaps carry out Mr. DeWinton's Rachenhalli Specification. The cost of this would be heavy, moreover the cost of buying up the tank, compensation that would have to be paid for the land submerged owing to increase of water spread, compensation for loss of crops under the tank, loss of Revenue, and realignment of the Railway, have all to be taken into account.

32. These remarks apply to Major Grant's para 59 as well. The mistake made seems to be that it is calculated that by making a small channel from a tank all the rain-fall due to the catchment of that tank can be secured, when really only a quantity of water equal to the capacity of that tank is obtained. It is no doubt this erroneous notion that has led Major Grant to consider it such a simple matter to connect different series of tanks with one another, while in reality it is by no means either simple or cheap. For instance, he treats it as an exceedingly easy matter to add 12 square miles of catchment to the Rachenhalli series, but the channel to take the drinage of 12 square miles would have to be very large. When the tanks are all in one series as at Hessarghatta they drain one into the other and no connecting channels are required.

33. *Paras G* 64 *to G* 66.—The cost of Major Grant's masonry dam seems reasonable, except that it is doubtful if the Hessarghatta rate for earthwork can be applied in this case ; judging from the description of the valley it will probably be

necessary to go some distance to get all the earth required; moreover, the lift is much greater. Several dams similar to those proposed have been constructed in the Province, and the cost can be approximately stated.

34. I may mention here that, judging from para 52 G, it would seem that the sites for the earthen dams have not yet been selected, nor have apparently the capacities of the reservoirs that will be formed been ascertained, and the difficulties mentioned by me in the preliminary report may therefore still exist. The objections to having 4 dams seem to me to be very great as they are four sources of danger and anxiety with the height of bund allowed by Major Grant. I am of opinion, that after a cyclone from N. E., none of his dams (except perhaps the masonry one) would be left standing. The designs, or sites, for the waste weirs have apparently not yet been settled, and this will not be altogether a simple matter; and I am of opinion that when all details are worked out, the earthen dams will be found to cost more than Rs. 3,90,000.

35. *Paras G 74 to G 79.*—The estimate appears to be fairly liberal and it is probable that the project will not cost more than 32 lakhs.

36. *Para G 86.*—Major Grant seems to attach great importance to the chemical purity of water, which of course shows the Hessarghatta Scheme at a disadvantage compared with the Maligal. The analysis of the water from the several tanks are so very slightly different that they do not prove much; moreover, it will certainly be found that the analysis varies. It is probable that if a little of the Hessarghatta water were sent to the chemical examiner now, the analysis would be quite different to the last. I believe the water of all these tanks have been analysed years ago, and if these analyses are compared with the ones lately taken it will be found that they vary considerably.

37. *Paras G 87 to G 89.*—These are chiefly a repetition of what has already been written and I have answered most of the arguments.

38. *Para G 98.*—There will be absolutely no delay in settling the compensation for the Hessarghatta Scheme, in fact the work to the reservoir will be begun in a few weeks, water-supply, or no water-supply. Where the delay will come in appears to me to be in the Maligal Scheme, as not even the exact sites for all the dams have been chosen, nor designs for the most important works such as waste weirs, water towers, &c., worked out, and this will have to be done before starting work.

39. *Paras G 91 and G 92.*—I consider the tables given by Major Grant as utterly useless for the reasons given in my paras 25, 26 and 27.

40. *Paras G 93 to G 100.*— These are more or less a repetition of what has been said before.

41. *Para G 100.*—Major Grant seems to have altogether misunderstood the Dewan's meaning, nearly all the tanks in the series above Hessarghatta may breach and no damage be done to the reservoir with the constructive details now proposed. Major Grant's idea "that the water-supply system instead of being entirely independent and complete in itself, capable of standing or liable to fall on its own merits only, would be hampered by the necessities and vicissitudes of the large chains of irrigation tanks above," is a most extraordinary one, and his meaning is very obscure. The Hessarghatta Reservoir will be quite independent of the necessities and vicissitudes of the tanks above. Major Grant makes much capital out of this remark of the Dewan's, and thinks it proves a very marked drawback to the Hessarghatta Scheme.

42. *Para G 101.*—The matter treated of in this para requires to be settled, by the British Government and the Mysore Darbar, and is no part of the business of an Engineer.

43. *Para G 103.*—Major Grant is correct on this one point in his report, and the amount I allowed for the establishment was undoubtedly too low. When writing I considered that the Municipal Engineer could both look after the general system, but I have altered my opinion and the sum of Rs. 7,000 provided by the Dewan, should be accepted.

44. *Para G.* 104—Major Grant takes, that 15 lbs of wood is required per N. H. P, this is a very large allowance, and with modern engines 5 to 6 lbs is nearer the mark. This would reduce the cost very considerably, but still the expenses will be high till plantations have been grown near the pumping station, *vide* my supplemental report, dated 22nd March 1893; but this is only one of many cases in which he has used unsound arguments to run down the Hessarghatta Scheme.

45. Major Grant's report is very lengthy, and the same arguments are repeated so many times in different places in different forms, that it is somewhat difficult to follow his reasoning, but the conclusions I have arrived at, after studying it are,—

1st that the Maligal Catchment is quite insufficient to give the supply required for the whole of Bangalore in a year of scanty rain-fall.

2nd. That the Maligal Catchment cannot be increased by 12 square miles for 2½ lakhs of rupees, he may get the water from two or three tanks for this money, but to obtain all the rain-fall available from the 12 square miles will cost at least 15 lakhs, consequently that this sum should be added to the cost of the project bringing it up to about 47 lakhs.

3rd. That there are serious objections to having 4 reservoirs, and perhaps 3 or 4 others in outlying villages.

4th. That as the exact sites for all the earthen dams have not apparently been fixed, nor designs for the waste weirs and water towers worked out in detail, Major Grant's estimate for head works must be accepted with caution.

5th. That he cannot increase the catchment of the Rachenhalli tank either easily or cheaply, and that the cost of buying up tanks and paying compensation for land will at Rachenhalli far exceed the amount required at Hessarghatta, so that even allowing for the extra distance of the latter it will be cheaper than the former.

6th. I am still of opinion that the Hessarghatta is the only catchment within a reasonable distance from Bangalore from which an unfailing supply can be got.

7th. That the opinion of one chemist, which is contrary to that of another regarding the quality of water, should not be accepted as a reason for rejecting the project when that water is known to be wholesome.

46. Major Grant has had about six weeks in which to write his report, but yet thinks it necessary to apologize for any mistakes that may have crept into it. How much more necessary is it therefore for me to apologize for any shortcomings, as I have only had 3 days, in addition to other work, to write my answer.

47. I feel that I am placed at considerable disadvantage, as, during that 6 weeks Major Grant has had ample time to think of every conceivable argument against the Hessarghatta Scheme, even to suggesting that mills and manufactories may be built on the catchment.

48. Major Grant does not seem to see one redeeming point in the Hessarghatta Scheme, but his contentions are not sound on many matters. There are many more points in his report that I would like to have dealt with, but I think I have noticed the more important ones, and I must leave it to Mr. McHutchin to answer the rest.

49. In conclusion I would remark that it is time the discussion on Bangalore Water-supply should cease after Mr. McHutchin's note is added to this, the subject will have been thoroughly thrashed out, and all possible arguments exhausted for and against the various projects that have been proposed at different times since 1839, and all that remains now is to decide which of the two projects is to be adopted.

50. Feeling so convinced as I do, regarding the uncertainty of the supply from the Maligal valley, I cannot too strongly recommend that, should the British Government decide to adopt Major Grant's Scheme, the Mysore Darbar should at once put in hand the Hessarghatta one as a separate supply for the Petta.

D. McNEIL CAMPBELL, Lt.-Col., R. E.,
Chief Engineer of Mysore.

Bangalore,
3rd April 1893.

REPORT

On the Several Schemes

HEBBAL—RACHENHALLI—HESSARGHATTA—MALIGAL VALLEY.

FOR THE

WATER SUPPLY

OF THE

Civil and Military Station and City

OF

BANGALORE.

PRINTED AT THE MYSORE RESIDENCY PRESS, BANGALORE

INDEX.

PART I.

General.

	Paras.
The situation in November 1892	1 to 6
The visit to Bangalore of His Excellency the Viceroy	7
Essentials to success in a Water-Supply Scheme	8, 9

PART II.

The Hebbal Scheme.

Captain Ward's Report	10, 11
His calculations for "*Run off*"	12, 13
Proposals for raising the dam	14, 15
Conditions affecting, and consideration of probable "run off"	16 to 21
Description of the Hebbal catchment	17, 18
Size of waste weir	22
Insufficiency of the catchment to meet the demands on it in a combined scheme and methods by which it can be enlarged	23 to 26
Probable cost of a joint scheme with Hebbal as the basis	27
Analysis of Hebbal water	28
The case "for" and "against" Hebbal and the question for decision	29, 30

PART III.

The Rachenhalli Scheme.

Mr. deWinton's scheme for the Civil and Military Station alone, and the conclusions arrived at by him	31
The requirements in a joint scheme and the power of the catchment to meet them ..	32
Facility with which the catchment can be enlarged	33
Cost of a joint scheme at Rachenhalli compared with Hebbal	34
Analysis of Rachenhalli water	35
The case "for" and "against" Rachenhalli and its marked advantage over Hebbal ..	36

PART IV.

The Hessarghatta Project.

Worked out under the orders of the Dewan Sir K. Sheshadri Iyer, K. C. S. I ..	37
Catchment area, and conclusions come to by Lieutenant-Colonel McNeil Campbell, R. E.	39, 40
Comparison between this area and that at Rachenhalli	40
Colonel Hasted's description of the rivers Pinnakinni and Arkavati	40
The difficulty of proper conservation of a large area	40
Reasons why, in the project the total cost is shewn to be so comparatively small in relation to the far greater distance and far greater lift than at Rachenhalli ..	41
The data, specifications and provision for ensuring proper conservation compared with those in the other projects	41, 42
Analysis of the Hessarghatta water	42
The water-supply of London, Liverpool and Manchester	43
The cost of a Hessarghatta scheme compared to that of one at Rachenhalli ..	44
The opinion of Colonel Mead when acting Chief Engineer of Madras relative to a Hessarghatta project	44

PART V.

The Maligal Valley Scheme.

Description of the natural catchment	45
Considerations as to "run off" with a comparison of Mr. deWinton's expectations in this respect, those formerly and now put forward	47, 48
Evaporation and percolation	49, 50
The population to be supplied in a joint scheme and the daily allowance	51
The power of the Maligal valley to meet the demand	52, 54
The ways in which the catchment can be increased	55 to 61
The specifications, etc., in the Hessarghatta and Rachenhalli projects and reason for giving alternative statements of cost in the Maligal scheme	62

	Paras.
The proposals now made differ considerably from those in the project for the Civil and Military Station prepared last year	63
Scope of the present project	64
The masonry and earthen dams	65, 66
The take off, filtering, and temporary storage arrangements prior to pumping ..	67—72
Pumps and engines	73
The rising main	74
The Service Reservoirs	75
Town distribution	76
Compensation for land and water	77
Analysis of water in the Maligal valley	77
Establishment, tools, plant, contingencies and unforeseen expenses	78
Cost of the Maligal valley scheme according to the two sets of data, &c... ..	79
The case "for" the Maligal valley scheme	80
The cost of the scheme for the Civil and Military Station only	81
The result in the Maligal valley of the rain on March 15th, 16th	82

PART VI.

General.—Conclusions.

Question of population to be supplied and the daily allowance	83
Summary of conclusions in Parts II to V	84
The advantages of Hebbal outweighed by the disadvantages	85
Rachenhalli versus Hessarghatta in respect to *quality*	86
Analysis of "Yellahanka" (one of the tanks in the Rachenhalli series) water ..	86
Rachenhalli versus Hessarghatta in respect to *quantity*	87
Relative cost of Hessarghatta and Rachenhalli schemes	88, 89
The only ways in which the much greater cost of the Hessarghatta scheme can be reduced	90
Abstracts of cost of Hebbal, Rachenhalli, Hessarghatta, according to the two sets of data and specifications	91
Comparative statement of the cost of the above schemes and of the Maligal valley scheme	92
Rachenhalli versus Maligal	93
The choice of the best scheme	94
The opinions of various officers about the Maligal valley	94
Result of excavations near site for dam at Nagarbhavi	95
Suitability of the Ketmarenhalli hill as site for Service Reservoirs	96
Ease with which the Maligal catchment can be enlarged	97
Difficulties attendant on taking up tanks	98, 99
What looks like a fatal blot in the Hessarghatta scheme	100
If Government of Mysore willing to provide whole of capital cost, choice must to great extent rest with them; possible conditions that might be made by the Government of India and the Civil and Military Station in this connection ..	101
Annual up-keep and working expenses in the four schemes	102 to 105
Hope expressed that this report may enable a decision to be come to, and that it may form the last of the long series extending from 1839 to the present day ..	106
The unqualified success of Sankey's tank in the drought of 1893	107

Enclosures to Report.

One 6″ map shewing the two towns and existing and proposed catchments.
One key map to the above on the scale of 1″ to the mile.

Bangalore (Civil and Military Station and Pettah) Joint Water-Supply Scheme.

PART I—GENERAL.

The situation in the middle of November 1892 was as follows :—The "Rachenhalli" project had been worked out in detail by Mr. deWinton who however was strongly against its adoption. After making allowance for fall in exchange, for increased size of service reservoir, and for compensation for land, the cost of this scheme stood at some 19 lakhs, exclusive of compensation to land-owners below the dam for loss of "spill." This scheme had not met with the approval of either the sanitary authorities or the Municipal Commissioners of the Civil and Military Station.

2. The cost of the Hebbal project, originally proposed by General Fischer R. E., (retired), had been worked out roughly by Captain Ward, R. E., who estimated it at 16¼ lakhs inclusive of compensation.

3. The Maligal Valley project had also been roughly calculated by Major Grant, R. E., and the possible cost put down at 21½ lakhs including compensation.

4. Each of the above named schemes dealt with the Civil and Military Station alone; and provided for a daily allowance of 2 cubic feet or 12½ gallons for 5,000 Europeans and 1 cubic foot or 6¼ gallons for 100,000 Natives—the numbers being arrived at from the last Census Returns.

5. A preliminary investigation had, it is understood, been recently started by the Mysore Durbar for a combined scheme for the Civil and Military Station and Pettah having for its basis the "Hessarghatta" Tank.

6. The orders of the Government of India on the case had been conveyed to the Resident in Mysore in M. D. No. 2691 M. W. of the 15th September and were to the effect following :—

(1). The Maligal scheme to be first worked out in detail through the agency of the Military Works Department and the result reported for information.

(2). A further report to be also submitted giving information on the following points :—

(*a*). The approximate cost of the Rachenhalli scheme including compensation.

(*b*). The approximate cost of the Hebbal scheme including compensation.

(*c*). Purity of the water obtainable under (1) and (2).

On the assumption that the cost of the Maligal scheme is about 20 lakhs of rupees and the maintenance perhaps double what has hitherto been estimated, the Government of India desired to be informed what proposals would be put forward with regard to the provision of funds for the execution of the works and for their maintenance and working when completed.

7. When it was anticipated, as was originally the case, that the cost of a suitable scheme would only be about 10 lakhs of rupees, the Government of India had undertaken to bear half the burden and the Civil and Military Station could no doubt have raised funds for the other half. But with the increased cost the difficulties, in the way of each, appeared to be insurmountable. At this juncture, *i. e.*, on the 22nd November, H. E. the Viceroy, Lord Lansdowne arrived at Bangalore and in his public utterances indicated the propriety on financial and other grounds of the adoption, by two towns, in such close proximity, as the Civil and Military Station and the Pettah, of a water supply scheme which should be common to both. The situation consequently underwent an entire change; and with it the scope of the duties in connection with which, the under signed was ordered to Bangalore.

8. It is proposed now to deal with each of the schemes referred to above relative to its suitability or otherwise to the enhanced demands, to be made upon it; but first of all what are, it is thought, the principal features of any successful water-supply enterprise will be enumerated.

1st. The quality of the water ought certainly to be the best procurable.

2nd. It should be in sufficient quantity to meet reasonable demands.

3rd. A scheme which after being carried out proves to be insufficient to meet the growing demands of an increasing population will not necessarily be a failure, always provided that it is capable of extension. On the other hand a scheme, which in execution, exhausts all resources, and is after all insufficient, can only be looked upon as a failure. Owing to the situation of Bangalore, in respect to the surrounding country, the cost of any good water-supply scheme must admittedly be great. But, as in private life it is a sound axiom to commence with a moderate establishment and expenditure so also it is thought should the water-supply question here be approached. In other words, the aim should be, not so much to carry out at once a complete scheme as to adopt one which will be capable of extension, as required from time to time, without a costly dislocation each time of its main features.

9. It seems to be the general opinion however that an allowance of $6\frac{1}{4}$ gallons a head, for the mass of the population is too small even to start with. Both the Brigadier General Commanding the Bangalore District and the A. M. O. dwelt on this point in their criticism of the "Rachenhalli" project. At Karachi where the water is brought in some 17 miles, but without pumping however, the allowance is 22 gallons. At Jubbulpur it is 15, at Nagpur 15. It is proposed in considering the joint scheme to take an all round allowance of 10 gallons per head per diem for 100,000 persons in the Civil and Military Station and for 80,000 in the Pettah. This will be the more convenient for the purpose of comparison with the Hessarghatta scheme in which those figures have, it is understood, been adopted. The total daily requirement will then be 2,88,000 cubic feet and the annual 105,120,000, say 105 M. cubic feet.

See paras 51 and 83 however

PART II.

The Hebbal Scheme.

10. The large map on the scale of 6 inches to a mile which accompanies this report and on which the catchments of the present sources of water supply and those of Hebbal, Maligal, etc., are shewn in different colors should be consulted when reading the next paragraphs.

11. The merits and demerits of the Hebbal scheme in relation to the supply of the Civil and Military Station only, are very clearly set forth in Captain Ward's Report which is attached and may be read. The experience gained, in working out the Hebbal temporary relief project tends to a conclusion that the allowance in Captain Ward's abstract for an 18″ rising main may be insufficient and that it would be safer to put this down at 140,000 instead of 1,20,000. Again from a detailed statement which has recently been prepared by the Superintendent of the Mysore Revenue Survey, it appears that the cost of land and water compensation may amount to 5 lakhs instead of 4,40,000. In round numbers these two additions bring up the cost of the scheme from $16\frac{1}{4}$ to 17 lakhs of rupees.

12. Captain Ward deals with a period of any five consecutive years, and assuming that there are 2 bad, 2 average and 1 good year, arrives at the conclusion that the total loss to the reservoir (consumption, percolation and evapora-

tion) during that period will be 620 M. c. ft. He calculates the gross inflow during the same period at 644 M. c. ft. and concludes therefore that for the Civil and Military Station (with an allowance of 2 c. ft. per diem for 5,000 Europeans and 1 cubic foot for 100,000 Natives) the supply from the Hebbal catchment is not likely to fail even in a bad series of years.

The margin is so small that if Captain Ward's calculations as to rainfall, run off, evaporation and percolation are correct it is out of the question to depend upon the Hebbal catchment as it stands, for the supply needed in a joint scheme for both towns.

13. Captain Ward's run off calculations are based on the following data:—

		Inches
(1)	Rainfall in worst year	16·54
(2)	,, average	30·65
(3)	,, best	45·60

(4) Run off $\frac{1}{7}$th of rainfall in each year—whence he arrives at the following per square mile of catchment :—

In bad year	6 M. c. ft.
In average	10 ,,
In good	14 ,,

The Hebbal catchment being 14 sq. miles the results become :—

In bad year	84 M. c ft. run off.
,, average	140 ,, ,,
,, good	196 ,, ,,

14. The proposal in Captain Ward's Report based on the above data, is to raise the Hebbal dam about 19½′ above present weir level and so obtain a storage capacity of 230 M. c ft. or 18 months' supply for the Civil and Military Station. This 230 M. c. ft. allows of a good margin between the calculated inflow in a good year 196 M. c. ft. and what he thinks it might actually amount to.

15. The proposal made by General Fischer in 1888 was to raise the dam 30 feet above weir level with the view of impounding 864 M. cubic feet of water ; the idea being to catch the surplus water of good years to supply the deficiency of bad ones. Both Colonels Bowen and Hasted R. E. who at the time were Chief Engineers of Mysore and Madras respectively were of opinion that a tank of the size proposed by General Fischer would never half fill; and the Government of Madras were of opinion that the scheme was open to such serious objection as to preclude the possibility of its acceptance.

16. The opinions of the two Chief Engineers above referred to are based on what are known as the Mysore data and these were arrived at by a series of observations made at Sankey's and the Ulsoor Tank. Colonel Bowen and the late Major Kensington R. E. who had a wide experience of Mysore, showed that from the Sankey tank catchment area of 2½ square miles the average available supply per square mile of catchment per annum had been 11 M c. ft., the maximum 17 M. c. ft. and the minimum 7 M c. ft. Mr. deWinton noted that these runs off were equivalent to

18 per cent in a bad year
15·4 ,, an average
16 ,, a good year

and believed them to be erroneous because (which is undoubtedly true) the percentage of run off should increase with the rainfall and not decrease. He also expressed his further belief that these runs off are in excess of actual facts because so much depends upon the nature of the catchment, and of the rain-fall; a short storm in a steep bare catchment producing a much greater percentage of run off, than long continued light rain on a flat highly cultivated catchment. It was for this reason that in the Rachenhalli project he adopted :—

6 instead of 7 M. c. ft. in a bad year.
10 do 11 do an average year.
14 do 17 do a good year

Captain Ward, as noted above took the same figures as Mr. deWinton. Looking to the fact that the Sankey catchment is for the most part artificial, water finding its way into the tank through miles of feeder channels it cannot be looked upon as an altogether reliable guide, but at the same time, although that fact is against a good run off result, the other fact of its being entirely free of cultivation favors such a result.

The following is an extract from the Minutes of Proceedings of the Institution of Civil Engineers Vol. XXXIX, section 1874—75, Part I. "The Nagpur water works, and the discussion thereon.

"*Major W. R. Johnson said he had lately been concerned in the restoration and improvement of the tank system in the Mysore Country in which there were no less than 30,000 reservoirs, and in carrying out this work it had been necessary to consider the proportion of rain-fall running off the ground. No accurate data were forthcoming but from rough observations made from works in action it was assumed at starting that not more than one-fourth of the rain-fall on an average found its way into the reservoirs. In one district in which the soil was light and sandy, and the greater portion under the plough even this was much in excess and the proportion there had been reduced to one-sixth. In reference to the collection of surface drainage, the nature of the soil, and the condition of the surface, were the first points for consideration. There being a great scarcity of water in the city of Mysore he had been sent to inquire into the matter and had ascertained that the tanks formerly filled much more readily than at present. On examination he found that cultivation had much increased in the catchment basin, what was before hard barren land having been ploughed up. After heavy rain, not a drop of water found its way into some of the supply or drainage channels, the whole having soaked into the ploughed land.*"

Mr. Binnie in his description said that at Nagpur "*for an average season's fall or 37·52 inches 38 per cent of run off may be expected, in a season the fall of which was that of the average of the three driest years or 30 inches, the discharge would be about 28 per cent, and in a year such as 1868 (the driest on record at Nagpur) when the amount of rain-fall was 19·28 inches about 15·5 per cent.*"

But then he had previously described the drainage area as "*a barren almost treeless, uninhabited tract of undulating and rocky ground.*"

17. The Hebbal catchment is colored green on the large 6″ map and its most distinctive feature consists in the three shallow depressions or valleys in which are situated three series of tanks namely.

(1). The depression with the tanks of Yeddahalli and Mattikere or Nagashettihalli.

(2). The depression in which is formed the Tanniranhalli tank.

(3). Finally the main valley in which there is the chain beginning with the Narshimpur and ending with the Hebbal tank.

The three depressions are separated from each other by spurs of rounded hills, and water falling in each eventually finds its way through the tank sluices and the heavily cultivated land below them towards the Hebbal Lake.

18. Another distinctive feature and one of very recent (1892) creation is the new line of railway which crosses the catchment in high embankment for the most part and divides it into two having to its North West the Tanniranhalli and three of the Hebbal chain and to the South East the remainder of the tanks. I have not by me the letter of Colonel Beresford Lovett, Chief Engineer, Madras Command, with which he forwarded Captain Ward's report but I think here marks in it, that the existence of this bank must exercise a prejudicial effect as regards the free run off of water into the Hebbal Lake.

19. The upper portions of the catchment are far more favorable being in parts free of even dry cultivation, and containing some steep slopes such as those above Kodigehalli and Tinnulu.

Just beyond the catchment between Chick and Dod Bettahalli is one of the rocky eminences characteristic of Mysore. To the North of the Tanniranhalli tank there is a considerable stretch of bare slopes ending in a wooded plateau. Below this to the West the railway line to Tumkur quits the Tanniranhalli depression and the Hebbal catchment in a long cutting. Roughly speaking the Hebbal catchment may be said to consist of :—

(a). Fairly favorable run off areas on its upper confines all round which in places approach to the definition given by Mr. Binnie of the Nagpur catchment.

(b). Most unfavorable run off areas, that is to say the shallow, heavily cultivated depressions which closely approximate to the description of ground spoken of by Major Johnson, as swallowing up water, falling during even heavy rain and preventing its getting into tanks below.

It seems evident that much of the water falling on *(a)* is drunk up in *(b)* and so ceases to become available.

20. In the face of so much theorizing it would be refreshing to have recourse to something practical as a guide. But unfortunately there is little to go upon. The Nagpur data are, it is true, the results of practical experiment but upon a catchment, which as a whole differs entirely from that at Hebbal to which they are not therefore applicable. General Fischer based his proposals for impounding 861 M. c. ft., of water on the discharges of the Hebbal tank during the period 25th September to 10th October 1888 but Mr. Larminie who was deputed to go into the matter reported that "*it is considered that there is ample evidence indirect and direct to show that the figures in question cannot be accepted, that they have been in fact enormously overestimated.* He then proceeded to treat the subject in great detail in a report dated July 1890. General Fischer in a note of the 17th November 1892, contends that he has proved that his calculations were correct and Mr. Larminie's all wrong. No useful purpose would, it is thought, be served by re-opening this question; Mr. Larminie's report having been placed before and considered by the Committee which assembled in July 1890, the late Colonel Sir Oliver St. John, having been President and Colonels Bowen and Tomkins, members.

Captain Ward mentions in his report that in August 1892 the run off into the tank was rather more than one-fourth of the rain fall, which was 6·88 inches, but he points out that this cannot be assumed for the whole year as August is one of the rainy months at Bangalore and the fall on the occasion, he mentions, was considerably above the average. The total fall in 1892 was 23 inches according to the Ulsur Rock Rain register and it appears that the Hebbal Tank did not surplus during the year.

21. The most that can be said is that even during a year of bad fall such as 23″ the run off may at certain periods of the year amount to 25 per cent and that in a year of extra good fall such as 45′ the run off may at certain periods amount to a good deal more than 25 per cent. But looking to the nature of the Hebbal catchment as described in the preceding paragraphs it cannot be assumed that the average runs off although they may exceed the $\frac{1}{7}$th allowed in Captain Ward's Report, can approach to those of a catchment like that at Nagpur. Instead of taking $\frac{1}{7}$th in each case, some allowance should however, it is thought, be made for a probably better percentage of run off in years of good fall.

One inch on a square mile gives 2·3 M. c. ft. of water so that the total rain-fall per mile of catchment becomes,

	M. c. ft.
In a bad year of 16·50 inches	40
In an average 30·65 ,,	70
In a good 45·60 ,,	103
In a bad year assume as before a run off of $\frac{1}{7}$th =	6
In an average assume $\frac{1}{6}$th instead of $\frac{1}{7}$th say =	12
In a good, assume $\frac{1}{5}$th instead of $\frac{1}{7}$th say —	20

The three assumptions as to run off per square mile of catchment compare then as under:—

Rain fall.	Run off per mile according to		
	The Mysore data.	Mr. deWinton in the Rachenhalli project and Capt. Ward in the Hebbal report.	Present assumption for Hebbal.
	Million cubic feet.	Million cubic feet.	Million cubic feet.
16·50″ *i. e.* a bad year ...	7	6	6
30·65″ an average year .	11	10	12
45·60″ a good year ..	17	14	20

Following again Captain Ward's plan of dealing with any five consecutive years and assuming them to be composed of two bad, two average and one good in relation to rain-fall, the following gross inflow is obtained:—

	M. c. ft.
Two bad years	$2 \times 6 \times 14 = 168$
Two average	$2 \times 12 \times 14 = 336$
One good	$1 \times 20 \times 14 = 280$
Total.....	784 M. c. ft.

During this period the quantity needed for a joint supply for the two towns will, according to the data fixed upon above, be $5 \times 105 = 525$ m. c. ft. But the amount lost in the same period would be according to Captain Ward's calculations for evaporation and percolation 396 million c. ft. with a reservoir holding 230 M. c. ft. *i. e.* for the supply of the Civil and Military Station only. With the greater waterspread needed for the joint supply the loss on this account would at a low computation amount to 450 M. c. ft.

Consequently we should arrive at

	M. c. ft.
Gross inflow during 5 years	... 784
Total loss during the same period ...	... 975
Balance (minus).....	191 M. c. ft.

If instead of accepting as correct the results of the registers kept at the Ulsur water works we take General Fischer's data as regards rain-fall the total rain-fall per mile would be:—

	Inches.	M. c. ft.
In a bad year of	17 ...	40
In an average of	35 ...	80
In a good of	56 ...	129

and the gross inflow during 5 years would be

	M. c. ft.
Two bad years	$2 \times (\frac{40}{7} = \text{say } 6) \times 14 =$ 168
Two average ...	$2 \times (\frac{80}{6} = \text{say } 14) \times 14 =$ 392
One good ...	$1 \times (\frac{129}{5} = \text{say } 26) \times 14 =$ 364
Total 924	
And the total loss being.....975	
The balance would be (minus).....	51

Under the most favourable circumstances the gross inflow into the Hebbal Lake during a period of 5 years would be 51 M. c. ft. less than the total demand during the same period, and it would be safer to assume this deficiency at 191 M. c. ft. It seems pretty evident too that the opinion of Colonel Bowen, that a tank constructed to hold 864 M. c. ft. as advocated by General Fischer would never under the most favourable circumstances even half fill is correct.

22. General Fischer in criticising Captain Ward's report notes that this officer, Colonel Bowen, and others propose to waste large quantities of water by constructing gigantic waste weirs and argues that the mere fact of their proposals in this connection go to prove his view of the case namely that the bund should be raised to give a tank capacity of 864 M. c. ft. But the argument is surely unsound for in designing a waste weir common sense dictates the adoption of a heavy margin of safety so as to preclude the slightest anxiety in the event of the occurrence of a cyclonic fall of unparalleled severity. It would clearly be out of place to base the prosperity of a water supply scheme on the possible occurrence of a cyclonic fall of such a nature.

23. There is seemingly only one conclusion to come to, namely, that the Hebbal catchment of 14 square miles is insufficient to meet the demands in a combined water-supply scheme for the two stations. The question which next arises is whether it can be supplemented artificially or otherwise.

The use of the Sankey's Tank catchment naturally suggests itself and from it an average annual run off of some 20 to 25 M. c. ft. may perhaps be counted upon. Heretofore most of this has been lost by leakage and evaporation. A portion of the former is however caught by the subsidiary small tank constructed some years ago by the Mysore Durbar below the main dam The overflow from this passes into the Jakrayan ravine and thence into the Jakrayankere near the Cotton Mill. The Durbar have recently constructed a bund across the ravine near the Cotton Mill and have laid a main of 12 inch piping; but for a combined scheme it may be taken for granted that they would permit the water from the tank immediately below the Sankey bund being pumped out of it either directly or *via* a filter bed into the service reservoir; which in the Hebbal scheme would be located on the slope of the adjacent Mantapum Hill. The Duplex pump which has been ordered out from England, for the Hebbal temporary relief operations would be permanently utilised for this purpose. But assuming that in this way we get an additional supply (allowing for percolation and evaporation) of from 12 to 15 M. c. ft. a year that will not make up the deficiency unless the rain fall of a period of 5 years aggregated more nearly to the averages of 17, 35 and 56 than to those which may be safely counted on of 17, 30 and 45. In any case a Hebbal—cum—Sankey scheme for the joint supply of the Civil and Military Station and the Pettah would not by itself comply with the 3rd condition noted in paragraph 8 of this report as one of the essentials to success namely that it must be capable of extension to meet yearly growing demands. After cultivation and irrigation had been stopped and the catchment had had time to recover from the bad effects thereof, it is conceivable perhaps that the supply might approach more nearly to the demand than it has been considered safe in this report to assume would be the case. But there would be no margin and before adopting the Hebbal Valley as the basis of a joint scheme the facilities for extending the gathering ground must be enquired into.

24. There is first of all the system of forming feeder channels to catch water falling on the reverse slopes of the catchment boundaries. These are shewn in yellow lines on Captain Ward's plan and might as thereon, stated afford an additional gathering ground of some 3 square miles. But considering the distance the water would have to be carried and the evaporation and percolation en route the resulting in flow into the tank would probably be very small and incommensurate with the considerable extra cost that would be incurred. It seems to go without saying that a catchment in which dependance has to be placed on such long lines of feeder channels of this class is not one to be relied upon. It is not proposed therefore here to take these channels into serious consideration.

25. Some 4 miles to the north in a direct line from the heights of Dod Bettahalli there is, it will be seen, a large tank called Honnenhalli or Rajankunte. This tank, in combination with those adjacent to it of Adiganhalli, Timsandra and Tarhunse, drains an area of for the most part bare, uncultivated and remarkably clean ground. The character of the country of the so called Bangalore table-land is very much the same the whole way from Bangalore to Nandidroog. Starting from the extreme south, near Malathalli and passing upwards via, Herohalli, Hegganhalli, Pinnya, Chick and Dod Bettahalli, Devanpalya, Rajankunte, Agrahar, etc., and beyond, towards Nundidroog, there is a more or less a continuous ridge from which the ground falls rapidly as a rule to the west and more gradually to the east. There is, too, a remarkable similarity in all this portion to the east. There are successions of arms of high ground jutting out from the main ridge to the east-south and south-east; and in the depressions and valleys between these arms or spurs are formed chains of tanks. Thus there are spurs running in a southerly direction on either side of Tarhunse. That to the east splits up again near Halsur and sends branches out east towards Chik-Jala, south towards Gantiganhalli and one S. E. forming a long stretch of high open ground towards Baiyappanhalli. There is a repetition of this sort of thing the whole way into Bangalore and in this way we find the following main chains of tanks.

I. Adiganhalli, Rajankunte, Harohalli, Yellahanka, Jakkur, Rachenhalli.

II. Narshimpur, Dod-Bomsandra, Hebbal, with the minor chains subsidiary to I of :—

(1). Tarhunse, Timsandra. | (3). Krishnasagur, Avalhalli.
(2). Nilkunte, Gantiganhalli. | (4). Virsagara, Anantpur.

and subsidiary to II of :—

(1). Tannianhalli. | (2) Geddahalli, and Mattikere.

26. As the main ridge and the portions of the spurs most adjacent to it are little cultivated it is clear that the clearest water will be found in the upper tanks of a series rather than in those lower down, before reaching which it will have encountered villages and assisted in rice and sugar cultivation. The water in the Rajankunte tank for instance is quite clear looking, compared to that in Rachenhalli or in Hebbal. There is no doubt then, that the water in a scheme based on the upper tanks in the two series would be purer than that drawn from the lower tanks of either. This point is however only mentioned incidentally here, the question immediately under consideration being how to add to the Hebbal catchment. The high ground between the two main series of tanks *i. e.* that stretching from Dod-Bettahalli to the north of Tinnalu and Kodigenhalli, precludes the running of water from the centre tanks of one series into the corresponding tanks of the other. For example it would be useless to propose direct communication between Yellahanka in one series and Hebbal in the other. And since Hebbal is higher than Rachenhalli water from the latter could not be brought to the former although the converse might, as will be noted later on, be arranged for. But a close examination of the country shewed that to run water from the Rajankunte or other tank situated high up in the one series into the Hebbal catchment might be feasible although it would at the same time be costly. A line of levels, starting from the waste weir of the Rajankunte tank and ending in the Hebbal valley was accordingly run and the result is depicted in Section No. 1 on the big plan starting from A, there is as far as B no difficulty, the line for a distance of nearly $1\frac{1}{2}$ miles following the contour. Then comes the spur which divides the sub-series Krishnasagur—Avalhalli from the adjacent sub-series Virsagara—Anantpur. In lieu of following the contour which winds round for several miles and which would entail heavier cutting further on, a tunnel might perhaps be decided on. The line actually taken goes straight through from B to C and D; and necessitates a tunnel a mile long. The length of tunnel might perhaps be reduced to nearer $\frac{1}{2}$ of a mile by carrying the line from B up the ravine south of Krishnasagur and then across through the hill into the ravine on the other side. It has not been considered necessary at this stage to work out which of the three ways of negociating this hill would be the most economical. From D to E is again plain sailing for a distance of about $1\frac{1}{4}$ miles. Then comes heavy cutting or another tunnel of about a mile in order to get through the northen slopes of the Dod-Bettahalli hill. Then the line gets into a ravine west of the same hill and little cutting is needed for a distance of

about 1½ miles from G to H. beyond which there would be a third tunnel of about a mile in order to get through the saddle and into the Hebbal valley near Narshimpur.

The above description is however for a level line but it would of course be necessary to give a continuous slope the whole way and also to start from a point about 6 feet below instead of from the W. W., level of the Rajankunte tank. The total distance is about 8½ miles and if the length of the three tunnels is taken at 3 miles there will remain some 5 miles of cutting of an average depth of say about 20 feet assuming a downward slope of 2 feet a mile. It would be necessary also to have a masonry channel of small section the whole distance so that in the passage from Rajankunte to the Hebbal series of tanks as little water as possible should be lost.

The cost would then work out something like what follows namely :—

		Rs
5,280 yards of tunnelling at say 100/ per yard	=	528,000
105,60,000 c. ft. of cutting at say 7/ per 0/00	=	73,920
8¾ miles of masonry channel at sayRs. 2/ a foot	=	92,400
	Total....	694,320

To this would have to be added the cost of compensation for land and water. The favorable nature of the catchment is evident by comparing its area, about 3 square miles, with the number and size of the tanks, Rajankunte, &c., into which the run off flows.

As the plan does not shew all the contours in this catchment its steepness is not apparent, but as noted before it is to a large extent bare of cultivation, and to this is largely attributable what is evidently a good percentage of run off to rainfall. Consequent on the bareness of the ground the rate for compensation should not probably much exceed what has been allowed for in the Maligal catchment say Rs. 40 an acre or say about Rs. 75,000. The cutting for the masonry duct would, at the same time, serve as a feeder channel and would convey into the Hebbal valley a large proportion of the rain falling on the high ground above it along some 5 miles of its course. There can, it is thought, be no doubt that with reinforcement thus afforded, the supply in the Hebbal tank would more than meet the demands in a joint scheme.

27. The cost of a joint scheme, with Hebbal as its basis, would be in round numbers about 29 lakhs, and adding to this the sum of 7 lakhs as in the preceding paragraph, the total cost becomes 36 lakhs.

For a population of 200 000

28. The following is a true copy of the analysis of a sample of Hebbal water taken from the tank in my presence on the 30th January last and forwarded to the Chemical Examiner, Madras, the same evening by mail train.

			Sample of water from Hebbal Tank, Bangalore
Total Solids	Grms per litre	..	.. 0·460
Volatile Solids ..	do	..	.. 0 120
Chlorine ..	do	..	.. 0 014
Total hardness ..	Clark's scale	..	.. 2° 450
Permanent hardness ..	do ..	..	.. 1° 400
Free Ammonia ..	Ml gms. per litre	..	.. Trace.
Albumenoid Ammonia..	do do	..	.. 0·400
Nitric Acid ..	do do	(as ammonia) ..	0 600

Apparent quality of the water as inferred from the results obtained on examination- F

Remarks.—The large amount of albumenoid ammonia is suspicious—probably it is due to vegetable contamination. Microscopic examination shows abundance of silicious particles, and plant and animal life in flourishing condition. The water contains a large amount of very fine clay and sand which passes through even a fine filter. Precipitation in a settling tank is advisable before filteration.

(Sd.)J. L. VAN GEYZEL, SURGEON-MAJOR,
Chemical Examiner.

In filling the bottles the greatest care was taken to ensure the contents being the best specimens of water that could be obtained from the tank. They were tied to the ends of long bamboos so as to project well away from the bund in the deepest portions of the tank; and were then filled about a foot below the surface so as to avoid surface impurities and at the same time ensure that there should be no stirring up of the mud at the bottom. This explanation is given, because I have heard it said that the analysis of Hebbal water previously taken did not afford a fair test since the specimens had been removed from a point in the tank close to where cattle are washed, drink, etc. It is most improbable that such could have been the case and this view is fully borne out by comparing the analysis above of the present character of the water with that below of its character in 1889 when the previous analysis was made by the same Chemical Examiner.

		Hebbal Tank
Total Solids	Grms per litre	0·160
Volatile Solids	do	0·090
Chlorine	do	0·014
Total hardness	Clark's scale	2·100
Permanent hardness	do	1·750
Free Ammonia	Mlgrms. per litre	Trace
Albumenoid Ammonia.	do do	0·210
Nitric Acid	do do (as ammonia)	0·750
Apparent quality of the water as inferred from the results obtained on examination		Suspicious.

Remarks.—Large amount of vegetable matter present in water, also fine clay sand.

(Sd.) J. L. VAN GEYZEL, SURGEON-MAJOR,
Chemical Examiner.

It will be observed that the quantity of albumenoid ammonia is greater in the present than in the former specimen and that altogether the water has if anything slightly deteriorated in quality. This is not surprising since there has been constant manuring and cultivation in the period of 4 years which has elapsed.

29. The case "for" and "against" "Hebbal" as the basis of a water supply system for the two towns may, I think, be summed up as under in relation to the three conditions put forward in paragraph 8 as essential to success in a scheme of this kind.

(1) The quality of the water is distinctly inferior, and it seems evident that many years must elapse before the tank and its catchment can recover from the ill effects of long continued manuring and cultivation.

(2) With the Hebbal catchment the water will be insufficient in quantity even with the Sankey catchment thrown in.

(3) But with the additional work described in paragraph 26 the quantity will be sufficient and the system will still be capable of extension when as years roll on, the population gets larger. By this is meant that should it become necessary the gathering ground need not terminate where shewn at present near Tarhunse but can be extended in a similar manner to the north towards Nundidroog.

30. The question for decision is whether it is worth while to spend so much money in changing what is now a favourable "*Irrigation*" catchment into what may after all, never, so far as quality is concerned, prove a really satisfactory *water-supply* catchment.

PART III.

The Rachenhalli Scheme.

31. A perusal of Mr. deWinton's Report shews that he sub-divided the total catchment of 36 square miles as follows, namely :—

	15 square miles of "free" catchment.
	21 square miles of "outlying" catchment.
Total	36

These areas are colored light red and green in the small Map with Mr. deWinton's Report and are surrounded with borders of the same colors in the large Plan now submitted.

He notes that the area of 15 square miles is not all, however actually free, because 8·67 square miles of it are the catchments of 5 small tanks lying in the neighbourhood of Rachenhalli and he did not therefore think it advisable to calculate on such a copious run off from this portion of the catchment as from the 6·33 square miles which form the actual free catchment of the Rachanhalli and Jakkur tanks the latter being situated immediately above the former, and being for the purposes of the scheme considered as practically the same tank.

He then sums up the sources of water-supply to the Rachanhalli tank thus.—

(1) Rainfall from its own free catchment of 6 33 square miles.
(2) Rainfall from the adjoining catchment of 8 67 square miles.
(3) Surplus from the outlying catchment of 21 square miles.
(4) Surplus of irrigation water from the large Yellahanka tank above.

In a year of good rainfall he assumes runs off of 14, 7 and 1 million c ft. respectively per square mile from free, adjacent and outlying catchments and reduces these further in bad and average years. He shews in a table the total runs off in 5 years and arrives at the following results :—

	M. c.ft
Total Inflow in 5 years	566
Total Expenditure *i. e.* the requirements of the Civil and Military Station + losses by evaporation, &c. ...	475
Balance.....	+91 M. c. ft.

and from these he concludes that if the reservoir is allowed to fill before any water is drawn off it should suffice for a Perennial supply at the proposed daily rate which was 39 M. c. ft. per annum for the Civil and Military Station, alone.

32. The annual requirement in the joint scheme is, it will be remembered, 105 Million c. ft. and in considering the capabilities of the Rachenhalli scheme to meet this demand it will be convenient to discard all except the two main subdivisions referred to in the preceding paragraph, *i. e.*, 15 square miles of free catchment and 21 square miles of "outlying" catchment. As the 5 small tanks spoken of by Mr. deWinton would all have to be breached or could be, if necessary, it will be fair to look upon the 15 square miles as free in the same way that the whole of the Hebbal catchment was considered free. The nature of the catchment is so very similar to that of Hebbal that it will be quite safe to assume the same runs off as in paragraph 21 of this Report, namely :—

6	M. c. ft. per square mile	in a year of bad fall of	16·50″
12	do	in a year of average fall of	30 65″
20	do	do good	45·60″

Dealing as before with a period of 5 consecutive years the following gross inflow is obtained.

	M. c. ft.
2 bad years	2×6×15=180
2 average	2×12×15=360
1 good	1×20×15=300
Total,,,,,,	840

	M. c. ft.	
Consumption during 5 years=5×105=	525	975
Loss by evaporation, &c., as before	450	
Balance (minus).....		135

Again taking as in the Hebbal valley, General Fischer's figures as to rainfall, the gross inflow works out thus.—

	M. c. ft.
2 bad years	2×6×15=180
2 average	2×14×15=420
1 good...	1×26×15=390
Total.....	990
And the total loss being.....	975
The balance would be	+25

In the Rachenhalli as in the Hebball scheme, the Service Reservoir would be located on the Muntapum Hill (see the Plan) and the water in Sankey's could also be pumped into it by the aid of the Duplex Pump obtained for the temporary scheme. With the additional supply thus obtained and in view of a better run off being obtained after cultivation had ceased for some years, it is conceivable that the Rachenhalli catchment of 15 square miles might meet the demands in a joint scheme for the water supply of the Civil and Military Station and Pettah.

33. Next as regards the facilities for enlarging the catchment to meet the growing demands of an increasing population. Unlike Hebbal there are no engineering difficulties in the way of an extension. It will be observed from the Map that the Rajankunte catchment the water on which can, as previously explained, be run into Hebbal for an expenditure of some 7 lakhs of rupees, forms also a small part of the "outlying" portion of the Rachenhalli catchment, as described by Mr. deWinton; and if necessary the whole of this 21 square miles can be added to the 15 square miles of catchment proper, making 36 in all. Moreover as noted by Mr. deWinton owing, to the lie of the ground the Hebbal and Nagavaram catchments can also be tapped; so that for (so far as engineering works are concerned) small additional expense the gathering grounds of the Rachenhalli catchment would agregate to over 50 square miles. This would suffice according to the above calculations for a population three times as great as that of the Civil and Military Station and Pettah combined. Where the expense comes in, would be in the matter of compensation but it would clearly be unnecessary at present to take up the whole of the 21 miles of outlying catchment or any part of the Hebbal or Nagavaram catchments. If, in addition to the 15 square miles, the Yellahanka tank and the catchment in its immediate vicinity say some 4 or 5 square miles be taken up, that would suffice for the requirements of both towns for many years to come. The cost of compensation of the 14 square miles of the Hebbal catchment will, as before explained, be some 5 lakhs of rupees inclusive of compensation for "spill." The price to be paid for the 15 miles of the Rachenhalli catchment proper may therefore be taken at 536,000 and allowing for the purchase of another 4 to 5 square miles, the entire charge for compensation would be approximately 7 lakhs.

34. The cost of a joint scheme with Hebbal as its basis has (see paragraph 27) been taken at 29 lakhs exclusive of the cost, some 7 lakhs, of the engineering operations necessary, in order to allow of the catchment being sufficiently augmented. Out of this 29 lakhs, 5 lakhs represent compensation for land and water leaving 24 lakhs for the primary engineering works. In the Rachenhalli scheme the lift is somewhat greater than in the Hebbal and the length of Rising Main will be about 4 miles instead of somewhat over two If on this account an extra 3 lakhs are assumed, the cost of the Rachenhalli scheme would work out exclusive of compensation to about 27 lakhs. Adding 7 lakhs for compensation for some 20 square miles of land and water, the total cost of a Rachenhalli Joint Scheme would be in round numbers 34 lakhs.

35 The following is the analysis of the Rachenhalli tank water made in 1889, simultaneously with that from Hebbal :—

Total Solids	Grms. per litre	.. ..	0·220
Volatile solids	do	.. .. ..	0·110
Chlorine	do	.. .. ..	0 025
Total hardness		Clark's scale . .	2°·800
Permanent hardness	do	.. .. ..	1°·575
Free Ammonia	Mlgrms per litre	.. ..	Trace
Albumenoid Ammonia	do	.. .. ..	0 200
Nitric acid	do	(as Ammonia) .	0 600
Apparent quality of the water as inferred from the results obtained on examination		.. .. ..	Suspicious.

Remarks.—Large amount of vegetable matter present in water, also fine clay sand.

(Signed.) J. L. VAN GEYZEL, SURGEON-MAJOR,
Chemical Examiner.

A comparison of the two analysis (see paragraph 28 above) tends to the conclusion that although both waters are under present circumstances of cultivation and manuring suspicious that from Rachenhalli is if anything the better of the two.

36. The case "for" and "against" Rachenhalli as the basis of a joint water-supply scheme may be put as follows :—

(1.) As in the case of Hebbal the quality of the water is distinctly inferior and many years must elapse before it can improve.

(2.) With the Rachenhalli catchment of 15 square miles together with Sankey's catchment it is conceivable that the quantity might be sufficient.

(3.) With the addition of the Yellahanka tank and its most adjacent catchment so as to make up 20 square miles in all, plus Sankey, the quantity should certainly be sufficient. Should the necessity arise, the catchment area can be increased to over 50 square miles without engineering difficulty of any kind. That area could be still further increased if the necessity ever arose by cuttings and tunneling. Like Hebbal the Rachenhalli has all the qualifications of a good cultivating and irrigating catchment. It will take a long time before the quality of the water will become what it ought to be in a water supply scheme.

The quality is slightly better than in Hebbal and the cost of obtaining a sufficiency at Rachenhalli is about 2 lakhs less in round numbers than of obtaining a similar quantity at Hebbal. Finally the Rachenhalli catchment can be increased if necessary without encountering any engineering difficulties up to over 50 square miles. It is as before a question for decision whether it is worth while incurring such heavy expenditure to obtain water such as this is likely to remain for many years to come but if that question is answered in the affirmative there seems no need of putting a second as to which of these two catchments should be adopted. The advantages of Rachenhalli are self evident

PART IV.

The Hessarghatta Project.

37. A preliminary Project for a joint scheme with this Tank as its basis has recently been worked out in considerable detail by Mr. R. T. Scaldwell, Executive Engineer, Bangalore Division, under the orders of the Chief Engineer and Secretary to Government, Mysore, in accordance with instructions given in October 1892 by the Dewan, Sir K. Sheshadri Iyer, K. C. S. I.

38. The Hessarghatta Tank lies about 11 miles, as the crow flies, to the N. W. of the Muntapum Hill above Sankey's Tank; the distances of the Hebbal and Rachenhalli Tanks from the same point being respectively $2\frac{1}{2}$ and 4 miles.

39. In the first 50 paragraphs of Mr. Scaldwell's report the catchment areas of the Hessarghatta Tank and of others in its neighbourhood, the condition and values of these tanks, the run off and matters of this kind are very carefully gone into. It is explained that the total catchment area of the Hessarghatta Tank and the 183 tanks situated above it is 211·78 square miles, of which the catchment area 22·78 square miles of the Hessarghatta, Byata, Kakol and the 5 minor tanks comprised in the project is free. In addition to these 22·78 square miles of free catchment, there is a partially free catchment of 8·85 square miles, and for purposes of calculation it is considered that half of it is free. A further additional area of 3·21 square miles can be obtained by throwing out of cultivation some four tanks, and all told a total free catchment of about 30 square miles is obtained. By raising the weir of the Hessarghatta tank 15′ the total capacity of the 8 tanks will be about 870 M. c. ft.

40. The conclusion arrived at by Colonel McNeil Campbell, Chief Engineer, Mysore, is that with the catchment area of about 30 square miles and a storage capacity of 870 million c. ft. there can be no doubt that an unfailing supply of 10 gallons per head per diem can be afforded to a population of 200,000. This last figure is arrived at by assuming that the present population of 180,000 will have increased in 10 years' time by 20,000 souls.

No useful purpose would, I think, be served by considering in detail the calculations of run off, rain fall, free catchment, &c, which lead up to the above conclusion. In dealing with the Hebbal and Rachenhalli schemes the conclusion come to was that with a catchment of from 15 to 20 square miles+the water in the Sankey reservoir, an unfailing supply of 10 gallons per head can be given to a population of 180,000 people. From the rainfall table given in paragraph 43 of Mr. Scaldwell's Report it would appear that the fall is considerably less than at Bangalore, and it would seem possible if not probable that the Hebbal and Rachenhalli catchments are more favorably situated in this respect than the Hessarghatta. Again the country in which this last named tank lies is more open than that of the Hebbal and Rachenhalli valleys, and it is again possible that as regards run off (irrespective of cultivation) the two latter are better placed than the former. Following the same train of thought still further, it is conceivable that if 30 square miles are needed for the effective supply of 200,000 people with the Hessarghatta valley as a basis, 25 square miles might suffice for the same supply in the valley containing the Rajankunte, Yellahanka, Rachenhalli series. Time and practical experience can only decide a question of this kind. but, always provided, that a catchment is capable of being readily extended should it prove insufficient in practice, it is immaterial in either case with how small an area, comparatively speaking, a start is made. It has been noted that without encountering engineering difficulties of any kind the Rachenhalli catchment can be extended to over 50 square miles and that by tunnelling, it can be further indefinitely extended in the direction of Nundidroog. As stated in Mr. Scaldwell's Report the total catchment area of the Hessarghatta tank and the 183 tanks above it is 211·78 square miles. The difference is great but the importance of this difference will only be so from a water scheme point of view if a catchment of over 50 square miles is ever likely to be needed for Bangalore. Twenty years hence it is calculated that the population will have reached to 241.437 people and even assuming that in the Yellahanka-Rachenhalli catchment 30 square miles are needed for the supply of 200,000 people, the 50 available should suffice for about 330,000. Many

decades would therefore pass away before steps would be needed to extend the 50 square mile catchment by engineering operations and it may, it is thought, be assumed that for all practical purposes the fact of Hessargatta and the tanks above it having a catchment of 211 miles confers upon it no benefit over Rachen halli and the tanks with it with the smaller catchment of 50 miles. From one, and that a very important point of view indeed there is a very distinct disadvantage pertaining to the larger catchment for it means increased care in the matter of conservation. Who for instance could positively declare that within the next half century mills and manufactories may not put in an appearance in the upper portions of this tract of 211 square miles. The area is too great to admit of permanent effective conservation. The broad conclusion to come to then, is that so far as quantity of water is concered there is no object in going 11 miles to Hessarghatta when requirements can be met within 4 at Rachenhalli. It has been stated that the Arkavati river to the west of Bangalore (on which the Hessarghatta tank is situated) and the Pennakinni River to the east are the only sources from which an almost unfailing supply can be obtained and that while projects have been prepared or proposed for getting large catchment areas nearer Bangalore by means of long contour channels extending to several water sheds and buying up a series of tanks none of them are by any means satisfactory. But Colonel Hasted R. E., writing in 1888 when Chief Engineer, Madras said "*The rivers Pennakinni and Arkavaty which drain the ground adjacent to Bangalore are not here rivers in the ordinary acceptation of the term in the beds of which water flows for some months in the year and is to be found below the surface of the bed for the rest. They are simply drainage channels which were dammed across at frequent intervals in old days to form the tanks which cover the face of the country.*"*

Practically therefore there is no difference in the circumstances of a water-supply based on the Rachenhalli series and of one starting from Hessergatta. The principle in both consists in buying up a series of tanks. Long contour channels extending to several water sheds would not be required at Rachenhalli any more than at Hessargatta.

The question of what proportion of the Rachanhalli series is "free" is purposely not gone into here because if it be decided to take up a series of tanks anywhere for a water-supply scheme the whole catchment can be made "free" if necessary.

41. Other things being equal it is clear that a scheme based on a tank (Rachenhalli) 4 miles distant from the site of the proposed service reservoir (the Muntapum Hill) ought to be very much less costly than another based on a tank (Hessargatta) 11 miles from the same objective. But it has been stated (see the end of paragraph 34 of this report) that in round numbers the cost of a Rachenhalli joint scheme for the supply of 10 gallons a head per diem to a population of 2,00,000 people would be 34 lakhs; while from Mr. Scaldwell's report it appears that the cost of the Hessargatta project for 2,50,000 persons at 12½ gallons per head per diem would ~~also~~ amount to 31 lakhs.

The reasons are not far to seek and summed up briefly are as follows.

I. The precautions to ensure a water tight earthen dam and service and other Reservoirs are far less elaborate and consequently far less costly than in the scheme for Rachenhalli worked out by Mr. deWinton.

In view of the far greater importance in a water supply scheme than in an irrigation project of preventing leakage to the utmost extent possible Mr. deWinton, for instance, proposed at Rachenhalli to leave the existing bund standing to assist in reducing pressure on the higher bund needed and which was to be of entirely new construction. At Hessarghatta the proposal is simply to raise the existing bund some 15 feet so as to arrive at a total height of about 30 feet Mr. deWinton gave a very strict specification to ensure in the construction of his bund the use of nothing but "*hard red Moorum of a clayey nature*" and the

*Vide report forwarded to the Resident in Mysore by the Government of Madras with their No 479 of the 14th July 1888.

inner slope was to be lined with slab stones 3″ thick on a gravel foundation and pointed with portland cement. In the detailed estimate prepared by Mr. deWinton for raising the Rachenhalli dam the rate works out to a little under 26 per 1000 cubic feet of dam whereas in the Hessargatta preliminary project the corresponding rate is about 12.

Again for his settling tanks, receiving and service reservoirs Mr. deWinton proposed vertical retaining walls offsets at intervals built on a two foot concrete foundation. The floors were to be of concrete 2 feet thick covered with stone slabs. In the Hessargatta project the proposal made by Mr. Scaldwell is to dig out the tanks with sides sloping 1 to 1 and to line these sides and the floors with Brick Work without apparently any concrete foundation.

II. In the Rachenhalli and all other projects heretofore it has been assumed.

This refers to pumping mains SG

(a.) That in accordance with the rule given in Molesworth's Hand Book the velocity of the water in the pipes must be kept well below 3′ a second; and this rule has regulated their size.

(b.) That pumping will only be carried out 8 hours daily. 12 Hours in the Maligal Project of last year. SG

(c.) That the floor of the service Reservoir must be placed at a sufficient height to command the whole station without any exception. SG

(d.) That in accordance with the usual ruling the diameter of the distribution pipes must be sufficient to allow of the daily supply being drawn off in a portion of the 24 hours only.

In the Hessarghatta Project.

(a.) The velocity in the pipes exceeds 3 feet a second ~~and no smaller pipes are proposed~~ SG

(b.) Pumping is to go on 13½ hours daily.

(c.) The floor of the Service Reservoir is placed 20 feet lower than in the other projects so that many portions of the station will not be commanded.

(d.) No allowance is made for the daily supply being drawn off within a certain number of hours. The rate for distribution heretofore has been entered at from 3½ to 4 rupees per head the allowance being 6¼ gallons a day. In the Hessargatta project the rate is kept the same while the amount to be carried by the pipes is exactly doubled.

III. In all schemes heretofore it has been proposed to buy up the catchments so as to ensure proper conservation and prevent cultivation. In the Hessarghatta scheme the only compensation allowed for is relative to the cost of the tanks themselves and the prohibition of wet cultivation below the bunds.

I have gone carefully into each item of the Hessarghatta project and find that if the scheme for the supply of 2,50,000 people at 12½ gallons a head per diem were carried out on the lines which have hitherto been accepted at Rachenhalli and elsewhere, the cost would rise from 31 lakhs as estimated to SG. over 50 lakhs. Conversely if the Hessarghatta lines be adopted for Rachenhalli the cost of the latter scheme will be enormously reduced. This will it is thought be self evident when it is remembered that most of the items such as receiving, filtering and service reservoirs, &c. are common to both schemes and may therefore be left out of consideration. The points in which the differences will occur will be in relation to the most expensive items namely—

Height of lift. | Distance of supply. | Amount of compensation necessary.

It goes without saying that if the lift is nearly doubled and the distance the water has to be carried is nearly trebled the cost of the scheme in which this occurs must be very much greater unless there are other counter balancing

eatures conducive to economy. So far as engineering works are concerned here are no counter balancing advantages at Hessarghatta over Rachenhalli. If the specifications in Mr. Scaldwell's project are accepted for Hessarghatta hey can equally well be adopted at Rachenhalli which will still have the great oull as regards lift and distance. Put the case how you may it appears incon estable that whatever be the cost of a water supply scheme for Bangalore with Hessarghatta as its basis the cost of a scheme for the same supply at Rachen-ıalli must so far as engineering works are concerned be many lakhs of rupees n favor of the latter.

42. It remains to consider whether this difference can be appreciably essened in the matter of compensation. The sum of 2,20,000 entered as compensation in the Hessarghatta project includes 1,20,000 as the value of the tanks to be taken up and 1,00,000 for wet land below them to be thrown out of cultivation. No provision is made as in the other schemes for buying up the catchment and removing villages. In that portion of this report which deals with a Rachenhalli joint scheme 7 lakhs are allowed as compensation for some 20 square miles of land, water, villages, and trees.

The question for decision in this respect is whether the Hessargatta catchment is so much cleaner and the water so much better than that from the Rachenhalli series, that these two sums of 2,20,000 and 7 lakhs accurately represent the cost of necessary compensation in each case. In paragraph 43 of Colonel McNeil Campbell's report on Mr. Scaldwell's project the results are given of the analysis of specimens of water from the Hessargatta and neighouring tanks made by the Chemical Examiner, Mysore.

This officer considers the water to be a good potable one although it might be a trifle less hard and writes in conclusion that "*in the event of these tanks being used as water scheme for Bangalore, it is presumed that they would all be conserved, in which case the water would be considerably purer than it is at present.*"

Colonel Campbell remarks in this connection that it will of course be necessary to conserve the tanks to the extent of preventing people bathing or washing their clothes, or cattle in them.

It will be noticed that in the Mysore analysis the quantities of the impurities are not specified and it does not therefore admit of ready comparison with those of specimens and water from other localities made by the Chemical Examiner, Madras. Under these circumstances I had specimens of the Hessargatta water carefully taken in my presence on the 17th February and despatched them to Madras for analysis the same evening.

The result is given below.—

		Sample of water taken from the Hessargh ıtta Tank, Bangalore.
Total solids	Grms per litre	0·250
Volatile solids	do	0·090
Chlorine	do	0·028
Total hardness	Clark's scale	5°·600
Permanent hardness	do	1°.050
Free Ammonia	Ml grms per litre	0·120
Albumenoid Ammonia	do	0 320
Nitric acid	do (as ammonia)	0·300
Apparent quality of the water as inferred from results obtained on examination.		Suspicious

(Signed.) J. L. VAN GEYZEL, SURGEON-MAJOR,
Chemical Examiner, Madras.

The water is described as "suspicious" and is certainly not a bit better than the specimen from Rachenhalli of which an analysis is contained in paragraph 35 of this report.—The conclusion to which one must naturally come is that if 7 lakhs of rupees are needed to ensure a pure water at Rachenhalli equally so will that sum be required for the same purpose at Hessargatta.

43. Both General Fischer in criticizing Captain Ward's Hebbal report and Mr. Scaldwell invite attention to the fact of the London water-supply coming from the densely populated Thames valley as a reason why much expense should not be gone to in the matter of compensation for removal of villages and prohibition of cultivation. I cannot think that the quotation is altogether a happy one, for the Thames is a deep river, with a rapid current, and the circumstances are entirely different to those holding here where the water flows directly off the land, through villages and manured cultivation into shallow tanks. The statement from Fennings treatise mentioned in Mr. Scaldwell's report says that in 1875 about one half the population of London or one half million persons received their domestic water supply from the Thames and that notwithstanding the strictest sanitary regulations which Government is able to enforce a great mass of sewage is poured into the stream. It is a well known fact that a mass of water in quick motion exercises a very purifying effect but even supposing that we had here in the Rachenhalli or Hessargatta catchment such a stream it would hardly be sound to adopt as our guide the circumstances of London of nearly 20 years back. This would be tantamount to throwing to the winds the experience gained during that period in London and other large English towns. That experience has led the towns of Manchester and Liverpool to seek for their latest water supply schemes, localities in the mountainous districts of Cumberland and Wales.

The gathering ground of the *Virniew* Lake with its high masonry dam is a bare thinly inhabited tract in the Welsh mountains, some 70 miles from Liverpool. The question of the improvement of the London Water Supply is one which is now engaging earnest attention at home one of the proposals being to follow the example of Liverpool and seek a pure supply also from Wales.

44. From time to time for years past the name of Hessarghatta has been mentioned as a possible basis for a Water Supply scheme; but in relation to the probable cost of such a scheme there has been nothing to go upon. All interested in the question—every inhabitant of the two towns therefore—is indebted to the Dewan of Mysore Sir K. Sheshadri Iyer for having had a preliminary project worked out so quickly, in anticipation of the day—not for distant now, at last, it is to be hoped, when a decision is to be come to after all these years of talking and writing. The result has been to show conclusively I submit, that the cost of a Hessarghatta scheme will be enormously in excess of a Rachenhalli scheme and will at the same time have no corresponding practical advantage in relation to either quantity or quality.

Colonel Mead R. E., then acting Chief Engineer, Madras, wrote in 1888 as follows:—

"*When at Bangalore, a scheme proposed by Colonel Vibart was brought to my notice. It is to bring water from the Hessarghatta tank in the Arkavati valley.* * * * * *This basin is open to the objection that there is extensive cultivation and several villages in it* * * * * *I do not consider it advisable for this scheme to be further thought of. It cannot be advisable to go to this distance from Bangalore and to incur the cost of this lift to obtain what cannot be considered a pure supply.*"

Colonel Mead's description of the situation relative to Hessarghatta appears to me to be as sound and logical now as it was 5 years ago. If the water supply scheme for an important place like Bangalore is to have for its main feature the utilisation of a series of purely irrigation tanks and a catchment which is not above reproach, in respect to cleanliness why go 11 miles, when what is wanted can be got equally well within 4 and with a corresponding saving of lakhs of rupees.

Residency Press, Bangalore.—11-3-93.—25.

PART V.

The Maligal Valley Scheme.

Decription of the catchment.

45. The natural catchment of 10 square miles is colored sepia on the large 6″ Map; and the most casual inspection will shew, how entirely different, its character is, to that of the catchments of the other schemes. The upper portions are traversed by numerous ravines, separating a succession of hills, with steep slopes. Lower down, the ravines meet, in a water way, which forms the centre of a valley with steep, and in places, approaching to precipitous sides. Rain falling on the upper hills, runs down at once, on both sides of them, into the ravines and thence into the main channel. A more favorable class of country for a good run off can hardly be wished for. During the whole of this season of drought there has been running water in the ravine starting from near the village of Pinnya and flowing south and east of the village of Laggere; and all down the main channel, there have been frequent pools of water on the surface of the sand; or else it has been obtainable by scratching holes in the sand. The rainfall registered at the Ulsoor Rock during the night of the 21st ultimo was 15 cents only and on the following morning I walked up the ravine, spoken of above, and found clear traces of a run off from the surrounding hills. When, to these favorable conditions, as regards run off, is added the fact that the country is very sparsely inhabited, has hardly any wet cultivation and not a very great amount of any cultivation at all; it is no wonder that it has been described by Mr. deWinton, as a typhical water-supply catchment and has been favorably remarked upon by every engineer who has visited it. Its general character, stamps it an excellent water-supply but a poor irrigation catchment, because the slopes are too steep and the ground too rocky for cultivtion. Hebbal, Rachnhalli, etc, on the other hand would be classed as good irrigation but poor water-supply catchments.

Considerations as to probable run off.

46. In my former report I noted that Mr. deWinton assumed that in the Maligal valley, a run off of 40 per cent, might be counted on, with a rain fall of 23 inches, but I added that it would not be wise to take this for granted unless it could be strengthened by some indirect outside corroborative evidence. Extracts were then given from lectures delivered at the S. M. E. Chatham in 1877, by Mr. Binnie, who designed the Nagpur Water Works. From these I pointed out, that there appeared to be a close resemblance, both as regards annual rain-fall, and nature of catchment, at Nagpur, and Maligal, and suggested, that we could not do better than take as our guide at the latter place in the matter of *run off*, the practical experience gained at the former.

At Nagpur with a fall of 19¼ inches, the run off was 15½ per cent, while with one of 43½ inches it was 40 per cent. I then assumed in the Maligal valley runs off varying from 13 per cent in a bad, to 25, in an average, and 40, in an exceptionally good year in lieu of the 40 per cent in a year of bad fall, as suggested by Mr. deWinton. The following is an extract from "*A comparison of the Rachenhalli and Magadi Road schemes*" drawn up by Mr. deWinton in 1890.

"*There being only 3 small tanks in this catchment (Maligal) all of which have surplused freely in the current year it is impossible to estimate the run off from any quantity of water stored; but a very well defined flood mark in the Maligal River, the proposed source of supply, affords accurate information under this head. This flood mark shews that for some period unknown, the river ran at a depth of 6½ above the centre of its bed. As this was evidently the highest flood of the year it may be taken as due to the heaviest rain storm. This occurred on the night of 26th August when 5·13 inches were registered at the Ulsur Tank. But the quantity registred at Hebbal on the same night amounted to only 2·68 inches; so, as Hebbal is near the head of the Magadi road catchment but is not so exposed to the south west I have assumed that the rain fall affecting the Maligal river amounted to 3 inches, distributed over 6 hours. Now this fall on 11 square miles amounts to 77 M. C.ft. or*

*13 M. C. ft. per hour, or 3,610 cubic feet per second. The area of water way of the Maligal river at the point at which my section was taken is 420·5 square feet with a central depth of 6½ feet and the fall at this point is 48·4 feet per mile, so that when the river was running at that depth it was discharing according to Kutter's formula 4,205 cubic feet per second and running at a velocity of 10 feet per second. Taking half this discharge or 2,100 cubic feet per second, as the average for the 6 hours of rainfall, the total run off would amount to 45 millions of cubic feet or nearly ⅗ of the total fall. An inspection of the respective catchments makes it easy to understand why the run off from the one should be so much greater than from the other * * * * * * * Assuming a run off of ⅖ which I firmly believe to be as much under the mark as ⅕ is over it, in the Rachenhalli catchment; and 23 inches to be the lowest probable rainfall of any future year, we get a gross supply of 588½ M. C. ft. and a run off of 235·4 M. C. ft. Allowing 50 per cent as before for evaporation &c., this leaves 117¾ M.C. ft. available for supplying Bangalore which is sufficient to give the whole town (Civil and Military Station and Pettah) a minimum supply for 2 years. And the great merit of this supply is that it can be relied upon because the catchment is bare and steep, and every storm of rain produces a fresh in the Maligal river, whereas, as I myself have seen, it requires very heavy rain to make any impression on the tanks in the Rachenhalli valley."*

47. I have quoted the above in extenso to show the grounds which Mr. deWinton had for his assumption for probable run off, as compared with the quantities assumed by me in my former report. It will be seen that Mr. deWinton calculated the actual run off during a certain night, at 60 per cent of the amount of rain that fell, and then assumed 40 per cent as the average, even in a year of bad fall. This assumption, is one, which clearly is open to dispute but from information with which I have become possessed in the last few weeks I am disposed to think that the runs off assumed by me, last year are very much less than they would be in practice. I sent last month to the Executive Engineer, Nagpur, a plan of the Maligal catchment and asked him to let me know how it compared as regards steepness of slopes with the gathering ground of the Nagpur Water Works. His reply was that the Maligal catchment is 25 per cent steeper than the other. Both catchments being generally similar, in respect to bareness and freedom from cultivation, it is clearly unnecessary to assume, as I did, a less run off than was found in practice to result at Nagpur. Mr. Palmer, the present Executive Engineer to whom I wrote has kindly sent for my perusal a portion of the draft of his Quinquennial report on the Nagpur Water Works. Mr. Palmer has taken great trouble in the compilation of tables and statistics, and I quote below, the following extract from his deductions. "*Now if it is required to find the probable off flow for a monsoon of 20 inches then this amount should be divided by the number of days from 8th June to 5th October the average date respectively of commencement and termination of the rains at Nagpur and the intensity of fall i. e., 0·168 is obtained; the diagram will shew that 19·5 per cent of the rain fall of 20″ will flow off the catchment area * * * * * * **

48. In view of the greater steepness of the Maligal catchment and the otherwise favoring disposition of the hills, as described above it is reasonable to assume a considerably better run off than at Nagpur; but even so it would not seem safe to adopt Mr. deWinton's anticipation of 40 per cent in a year of bad fall of 23 inches.

The following would not however seem to be too sanguine an expectation namely:—

25 per cent or ¼	in a year of	bad fall of	16·50
40 per cent or ⅖	,,	average	30 65
45 per cent or 9/20	,,	good	45·60

Remembering as before, that one inch in a square mile gives 2·3 Million C. feet of water so that the total rain fall per mile of catchment is—

				M. C. ft.
In a bad year of	16·50	inches	.. ..	40
In an average	30·65	,,	.. ..	70
In a good	45·60	,,	.. ..	103

the run off per mile according to the above forecast would be :—

$\frac{40}{4}$=10 M. C. ft. instead of 6 to 7 M. C. ft. in a catchment like Hebbal
$70 \times \frac{2}{5}$=28 M. C. ft. instead of 10 to 12 M. C. ft. do do
$103 \times \frac{9}{20}$=46 M. C. ft. instead of 14 to 20 M. C. ft. do do

{See para 21, part II of this report.}

At a recent meeting at the Residency, Mr. Scaldwell, if I am not mistaken, expressed an opinion that the run off in Maligal valley might be taken as double that in the Sankey catchment. The runs off anticipated above, are not much greater than that. If, instead of accepting rain falls as above which are the results of registers kept at the Ulsoor Water Works where the gauge is a considerable height above the ground, the falls are taken at 17″, 35″ and 56″ the total fall per mile of catchment would be :—

	M. C. ft.
In a year of bad fall of 17″ as before say ..	.. 40
In a year of average fall of 35″ „ ..	.. 80
In a year of good fall of 56″ „ ..	.. 128

The run off per mile would then be :—

$\frac{40}{4}$ =10 M. C. ft. in a year of bad fall
$80 \times \frac{2}{5}$=32 M. C. ft. „ average
$128 \times \frac{9}{20}$=58 M. C. ft. „ good

With the 10 square miles of catchment in the Maligal valley, the runs off would therefore be either,

10×10=100 M. C. ft. in a year of bad fall
10×28=280 M. C. ft. in a year of average fall
10×46=460 M. C. ft. in a year of good fall

or

10×10=100 M. C. ft. in a year of bad fall
10×32=320 M. C. ft. in a year of average fall
10×58=580 M. C. ft. in a year of good fall

Even in the latter case the run off in a year of bad fall of 17″ is less than one half of what Mr. deWinton calculated it would be, assuming as he did that a rain fall of less than 23″ is not likely to occur. Practical experience alone can prove whether Mr. deWinton's estimate is too sanguine. Looking to the steepness of the valley it cannot, it is thought, be positively asserted, that he is wrong, and it would seem quite safe, to count upon runs off varying from 100 M. C. ft. in a year of exceptionally bad to 500 M. C. ft. or 600 M. C. ft. in one of exceptionally good fall.

Evaporation.

49. In my former report, I allowed $\frac{1}{5}$″ per diem for evaporation In his report on a Hebbal Project, Captain Ward went very closely into this question and drew up a table from which he arrived at 3·65 feet as the depth of water likely to be lost in a year on this account at Bangalore. It seems to be generally admitted, that evaporation is increased, not so much by a rise of temperature, as by a windy day. As the lower portions of the Maligal valley are so much exposed to wind than Hebbal, it is possible that evaporation there, might be less. But this cannot be calculated, or counted on, and it will be convenient to assume Captain Ward's figures as correct. In the Maligal valley the water spread of a lake with capacity of about 108 M. C. ft. is 124 acres and taking an average spread of 100 acres throughout the year the loss by evaporation, works out to 43,560×100×3·65= say 16 M. C. ft.

Percolation.

50. In the former report, 20 per cent of the capacity of the Reservoir was assumed as lost by percolation. This was I think a mistake, and for the following reason. The water-spread of a Hebbal lake to contain 280 M. C. ft. is, from Captain Ward's report,

525 acres, and the same amount of percolation is allowed *viz.*, 20 per cent. In the case of Maligal 87 M. C. ft. of water go to 100 acres whereas at Hebbal the same area only gives a capacity of 44 M. c. ft. At Maligal the area, in which percolation can occur is half what it is in a shallow catchment. It is not I think unreasonable to suppose that the per centage of loss should also be halved. It may be objected that with the increased depth of water the pressure would be greater and consequently there would be more percolation on the same area, but in view of the ground in the Maligal valley being so hard, and not having been disturbed by cultivation it is thought, that this would not be the case. Allowing then, 10 per cent the loss on this account in a tank of a capacity of 100 Million C. ft. would be 10 Million.

Population to be supplied and allowance per head per diem.

51. The next point to consider is the population to be supplied and the allowance per head. In paragraph 9 Part I of this report, 10 gallons per head for the existing population of 1,80,000 were mentioned. But the Hessarghatta Project deals with $12\frac{1}{2}$ gallons per head for 2,50,000 people or alternatively 10 gallons per head for 2,00,000. To carry out the bigger proposal would mean that the present generation would be paying for the benefit of those succeeding it; and having regard to the present financial outlook it may I think be taken for granted that the Government of India would be quite unable to share in such an arrangement. The first estimate submitted by Mr. deWinton provided 15 gallons per head for the mass of the population of the Civil and Military Station but this was found to be too expensive and the allowance was reduced to $9\frac{1}{4}$ and eventually to $6\frac{1}{4}$. In view to providing for an increasing population, the latter figure, has in the portions of this report referring to Hebbal and Rachenhalli, been again raised to 10 gallons for the existing population; and it is for consideration, whether it will be found financially possible to do more than that at present. But as Colonel Mc Neil Campbell has recommended the adoption of a rate of 10 gallons a head for 2,00,000 in his report on the Hessarghatta scheme those figures will be adhered to in the Maligal.

The power of the Maligal valley catchment to meet the demand.

52. For purposes of calculation, it will now be assumed that 4 lakes or tanks are formed in the Maligal valley each with an average waterspread at full tank level of about 124 acres and a capacity of about 100 to 108 Million cubic feet.

The consumption per annum at the above rate will be

$(2,00,000 \times 10 \times \frac{4}{2^5} \times 365)$ C. ft. = 1,16,800,000 C. ft.
= say 117 M. C. ft.

In each tank, the losses by evaporation, and percolation will be, in terms of the preceding investigations, 16 Million and 10 Million C. feet respectively. If now we take as before a period of 5 years and assume them to consist of two with a bad, two with an average, and one with a good rain-fall, the gross in flow will be as under, with the natural catchment of 10 square miles.

			M C ft.
2 years of bad fall	.. 16·50″ ...	2×100 =	200
2 years of average fall	.. 30·65″ ...	2×280 =	560
1 year of good fall	.. 45·60″ ...	1×400 =	400
		Total inflow....	1,160

The corresponding consumption and waste will be.

		M. C ft.
Consumption	5×117 =	585
Evaporation	4×5× 16 =	320
Percolation	4×5× 10 =	200
	Total.....	1,105

So that there would be a balance of about 55 Million C. feet, exclusive of the water in Sankey's Tank, which in this, as in the other schemes, it is proposed to indent on, using, eventually for this purpose, the pump now on its way out from England for the temporary water supply scheme.

53. If the higher rain falls arrived at, by making an addition to the results registered at the Ulsoor rock be accepted the state of the case would be:—

Gross inflow.

				M. C. ft.
Two years of bad fall say 17″ as before	...	...	200
Two „ average „ 35″ „	...	...	640
One „ good „ 56″ „	...	...	400
			1,240
Consumption and waste.....			1,105
Balance.....			+135

exclusive as before, of the water impounded in Sankey's tank.

54. If Mr. deWinton's estimate as to run off prove correct the supply of water passing through the valley will be still more in excess of the demand. Without going so far as to say that his estimate is more likely to be correct than mine I think there need be no hesitation in saying that the run off of rain fall here, will be found ample for both towns; not only now, but for a long time to come. The difficulty is not, as is often said, in respect to an insufficiency of water but as regards the cost of storing it. A day spent in walking along the hills, and down the ravines of the Maligal valley will do more to convince, as to the amount of water that yearly passes through it, unutilised, than weeks spent in wading through calculations and reports. Since however, the question is not one, which admits of a mathematical demonstration, it would clearly be going against the third of the principles enumerated in paragraph 8, as essential to success if the final adoption of the Maligal valley as the basis of a water supply scheme, were recommended without explaining how, if surmises are after all not fully realized the situation would still be susceptible of easy remedy and adjustment

How the catchment can be increased.

55. It is proposed now therefore, as was done in the cases of Hebbal and Rachanhalli to consider how and at what cost the natural catchment of the Maligal valley could if found necessary be artificially extended.

56. It will be observed that the southern boundary of the green colored Hebbal catchment, and the northern boundary of the sepia colored Maligal catchment are common and that in the vicinity of the point marked O, on the Tumkur road, about half way between Yeshvanthpur and Pinnya there is a saddle; from which, the slope, into the Hebbal valley, is slight, while into the Maligal it rapidly becomes steep. Within the Hebbal catchment distant half a mile from O is situated the Tanniranhalli tank, the waste weir of which is 2962·74, while point O near to which the rapid fall into the Maligal valley begins is about 2,971. The catchment of this tank is surrounded with a venetian red border over the green and it is evident that by raising the W. W. and making an insignificant cutting to the south west water falling on this gathering ground can be made to run into the Maligal valley—vide longitudinal Section No. II. It has been mentioned above, that it is proposed to form 4 lakes in the Maligal valley, and one of these would probably be located in the ravines between Laggere to the west and Garudachari Pollium to the east. If a masonry duct of small section, be made along the centre line of the cutting, so as to connect the Tanniranhalli tank with the new lake, water in the former will be readily accessible to the latter. Near point L. there is a bridge over a gap in the railway embankment and all that will be necessary will be to lower the ground level under this bridge some 3 feet and carry on the cutting in the direction M. N. O. P. Q. until the point is reached where the fall into the Maligal valley becomes rapid. The greatest depth of the cutting will be 15 feet and it will be on the safe side if an average depth of 10 feet is assumed for a distance of 5 furlongs. Assuming a depth at bottom of 5 feet, and side slopes of 45° the quantity of cutting works out to 4,95,000 cubic feet which at say 7 Rs. per 1,000 would cost about 3,500 rupees. The length of the masonry duct would vary according to the exact site chosen for the new lake from 1½ to 2 miles. Assume 2 miles and a rate of 3 Rs. a foot and the cost will be about 32,000 rupees. Allow 5,500

rupees for alterations to bridges, raising W. Weir, &c., and the total will become 43,000 rupees. As the masonry duct neeed only be of small cross section, the cost would probably be less than 3 Rs. a foot so that 43,000 rupees may be regarded as the outside cost of adding some 3 square miles to the Maligal catchment. This area consists of large stretches of uncultivated ground, and wooded land, also dry but no wet cultivation. In describing in Part II of this report the Hebbal catchment it was explained that it consisted of a higher portion, answering to the description of a good water supply, and run off area and of another lower portion forming a bad water supply catchment, owing to flatness of slopes and amount of wet cultivation. The portion of the Hebbal catchment within the venetian red border and which can be added to the Maligal at a cost of 43,000 rupees inclusive of a masonry channel falls within the former category.

57. In addition, by running a feeder channel starting from the high-ground (3089) north of Hebbal lake and passing east of Tinnulu, Narsimpur, and Dod Bomsandra to the Tanniranhalli tank the catchment area of the latter can be increased by some 3 square miles, by the portion surrounded with a burnt umber border, over the green. As this feeder channel can have as steep a gradient as desired it clearly would not be open to the disadvantage of excessive percolation en route, which marks the feeder channels of Sankey's tank. The cost would vary with the section of cutting determined on, from say about 10,000 to 15,000 rupees. Large tracts of this area are bare and uncultivated and the slopes in places are steep. Briefly, two areas each of 3 square miles forming the highest, cleanest and steepest portions of the Hebbal catchment can be added to the Maligal at an outlay for works of 43,000 and 10 to 15,000 respectively.

58. In view of the Maligal valley being so much lower than the Hebbal the Chief Engineer of the Madras Command, Colonel Beresford Lovett is I understand inclined to think that water from the latter finds its way by natural percolation into the former. This opinion is borne out by the existence of springs in the Maligal valley.

Before passing on to the consideration of the extension of the Maligal catchment to the south it should be noted that the waters of the Rajankunte and the other tanks at the head of the Yellahanka, Rachenhalli series can equally well be run into Maligal, as into Hebbal by a modification of the proposals described in paragraphs 25, 26 Part II of this report.

As the necessity for such an extension would certainly not arise for a very long time to come, the question of the additional cost of the modifications needed, is not entered into.

59. Turning now to the southern portion of the Maligal valley it will be seen that starting from Hegganhalli and spreading out like a fan to the west and southwest there are a series of steep hills, with ravines on either side, which are very similar in general character to the valley itself. Water falling within the area marked by a sepia border finds its way into the tanks of Hallal and Malathalli and from these it can be conveyed along the line S. T. U. V. W. X. in slight cutting and one tunnel to the point X close to the Waste Weir of the proposed lake at Nagarbhavi. See Longitudinal Section No. III. Starting from the Malathalli tank the line winds round the spur of the hill on which the village of that name is situated; then up the ravine east of the village, and by means of a tunnel into the Maligal valley. The length of cutting would be about $1\frac{1}{2}$ miles of an average depth of say 10 feet and of the tunnel about $\frac{3}{4}$ of a mile. If along the centre of the cutting a masonry duct is inserted as before the cost would be roughly as follows :—

About 12,00,000 c. ft. earth work at say...	8 Rs.	=	9,600
„ 1,320 yards of tunnel at say	...100 „	=	1,32,000
„ 7,920 feet of masonry duct at	... 3 „	=	23,700
	Total.....		1,65,360
	Say.....		1,70,000

The price of tunnel for the Loch Katrine, Water-works for Glasgow, made through clay slate was between £ 9 and £ 10 per yard, its height and

width being 8 feet, giving a sectional area of some 6 square yards. The length of the Snowdon tunnel at Ootacamund is 350 feet and it is lined with brick work. It was cut through a mass of rock and earth abounding in springs by a small party of the Madras Sappers in the course of 8 months. Its width and height, measured inside the lining, is 1′ 8″ and 3′ 7″ respectively and it cost 60 rupees per yard. The tunnel between the Malathalli and the Maligal valleys would be much the same size as that at Ooty and the rate allowed above, of 100 rupees per yard is probably an outside one. The Malathalli valley is more cultivated than the Maligal but is bare compared to Hebbal or Rachanhalli and from the bareness and steepness of its slopes approaches far more nearly to the Maligal than to those valleys. For an outside expenditure of 1,70,000 its area, as shewn within the sepia colored border, of about 4 square miles can be added to the Maligal Catchment.

60. The winding red line starting at X and going south and then west represents a contour at the same level as the waste weir of the proposed tank and if necessary a considerable further amount of catchment could be added. But as in the case of Hebbal, so here it is not proposed to take into consideration a long winding feeder of this class.

The case therefore stands thus

	Sq. Miles.
Natural catchment of Maligal	10
To which can be added :—	
At a cost of Rs. 43,000 from Hebbal	3
At a cost of ,, 15,000 do do	3
At a cost of ,, 1,70,000 Malathalli	4
At a cost of the Sankey catchment of ...	2
Total Rs. 2,28,000	
Say 2½ lakhs	22

61. Beyond these 22 square miles, the catchment can be further if necessary extended for many miles to the north similarly to Hebbal, and also by feeder channels to the east, south, and south-west. Since the catchment can in this manner be more than doubled at a cost of 2½ lakhs and still farther if necessary, generations later on, there will be no risk in adopting it for a water-supply scheme. But as it is believed that owing to the nature of the hills, their steepness and bareness the ten square miles of natural gathering ground supplemented by the water in Sankey's will prove sufficient it is not proposed to include any portion of the expenditure for extensions, in the estimate of initial cost of the scheme, the details of which, for the joint supply of the Civil and Military Station and Pettah, will now be considered.

NOTE
See in this connection paragraph 82.

62. Before doing so however it is necessary to revert again to the matter of specifications. In Part IV of this report it was pointed out that the proposals in the Hessarghatta project were in many respects of a far cheaper nature than had been considered necessary in the projects that had preceded it. Again the time allowed for pumping and the velocity in the pipes were much greater than in these projects and these facts tended to very considerable economy. Pending a final decision on these points it is proposed in the Maligal joint scheme to give alternative statements of cost wherever necessary.

Data and specifications in the Hessarghatta project and those heretofore accepted.

63. In many respects the proposals now put forward will differ from those in the scheme for the Civil and Military Station only, submitted last year.

Proposals now, differ from those made last year.

64. The following is a brief description of the scope of the present project.

Scope of the present project.

A. Construct a 60 foot masonry dam near Nagarbhavi on the site described in the former report and three other earthen dams each about 50 feet high so as to impound altogether about 400 million cubic feet of water.

B. Water from the lowest lake at Nagarbhavi to pass through a tunnel outlet into a regulating well and thence into filters and a clear water tank in the immediate vicinity of the lake as already described.

C. Then pump it up from the clear tank at the rate of 10 gallons a head per diem for 2,00,000 people equivalent to 3,20,000 cubic feet a day through,

D. A rising main 4 miles, 390 yards long into,

E. A seven day's service Reservoir to be located on the flat topped hill above the village of Ketmarenhalli, of which a plan is given at the foot of the big 6 inch map.

F. From this service Reservoir which will be in two divisions one for the Civil and Military Station and one for the Pettah, separate gravity distribution mains will start to each town.

The floor of the division of the Reservoir devoted to the Civil and Military Station to be at, or about M S L 3,070 and that of the other for the Pettah to be at M S L3,055 so that every point of both may be thoroughly commanded and a good head of water be available at every stand post.

G. The size of the distribution mains to be sufficient to allow of the day's supply being drawn off from 8 to 12 hours.

The Masonry dam.

65. For a description of the site at Nagarbhavi where it is proposed to to erect the masonry dam and of the nature of the proposals generally, reference is invited to the following paragraphs of the former printed report dated 25th April 1892, namely.

Paragraph 66

Paragraphs 69 to 78.

The cost of those proposals aggregated, it was then explained to approximately Rs. 4,75,000.

The following modifications are now proposed.

The dam to be 60 feet in height above the reef of trap rock and the section to be sufficient for that height only, instead of sufficient for a dam of 70 feet. The original proposal was to make the dam 55′ high only, but capable of being raised to 70 feet. The site is better suited to a 60 feet dam than to one of greater height and as other dams are now proposed higher up, the necessity for the greater section no longer holds. It was originally proposed to construct the dam, where pucca, entirely of Portland cement concrete. It has since been ascertained that a good hydraulic lime is obtainable about 40 miles distant on the Mysore railway at Muddur and it is now proposed to build the dam of uncoursed stone masonry in Muddur lime mortar. Forty rupees were allowed for the Portland cement concrete, and for the masonry now suggested it is thought that 25 per 100 cubic feet should suffice; bearing in mind, that barring the lime, the other building materials, stone, sand, clay, water are available at site.

Experimental excavations which have now been made shew that it will be necessary to put in concrete foundations to a depth of some 8 feet before sound rock is come to, between the two lines of trap of which the reef consists. Again on the inner side of the inner line of trap about 8 feet must be cut away before sound rock is come to. The filling between the two lines of trap shall, it is proposed, be of concrete with lime mortar but for the puddle wall about 7 feet wide and 8 feet deep on the inner side, of the inner line of trap the concrete will be in Portland cement. This system of having an inner puddle wall of cement concrete is copied from that adopted at the Virniew dam of the Liverpool water works, and is, it is thought a necessary precaution against leakage, at the most vulnerable point namely across the bed of the stream. This inner concrete walling will gradually tail off, as the dam foundations rise with the banks of the river on either side.

In addition to the centre dam of concrete and pucca masonry, there will as before, be an earthen flank on each side. The length of the masonry

centre will be 823 feet at the top and the lengths also at the top of the earthen sides will aggregate to 1,310 feet. As explained later on, it is intended that there shall be no sluice in the dam itself, the arrangements for running off water being located elsewhere. In the former report there was a clerical error (see page 24) in respect to the rate for the earthwork this having been entered per 100 cubic feet instead of per 1000.

A detailed estimate for this dam at Nagarbhavi has now been got out and it amounts to 2,21,712 rupees. This sum includes rates for earthwork 7, and clay puddle 12, corresponding to those allowed, in the Hessarghatta Project. It also provides for stone pitching the water faces of the earthen portions in mortar, and pointing the same with Portland cement, and for turfing the outer slopes and the summits, instead of, for a mere dry stone revetment. It provides in short for a specification something between that of Mr. deWinton at Rachenhalli and Mr. Scaldwell at Hessarghatta. The earth for the sides at Nagarbhavi is close at hand but if it is to be laid watered and rammed in 6″ layers as proposed at Rachenhalli it will be safer to adopt Mr. deWinton's rate of 17—per 1000 cubic feet for earthwork instead of 7—in which case about 16,000—should be added to the total figure given above. That figure already includes an allowance of 5 per cent for contingencies but it will be safer to double this and make it 10 per cent. Including this the cost of the Nagarbhavi dam, with Mr. deWinton's specifications for the earthwork, will amount to approximately 2,48,000 and with the Hessarghatta to 2,32,000. The details of the Waste Weir have not yet been got out and on its account the sum originally entered of 10,000 will be provided here. Adding this, the cost of the dam at Nagarbhavi will be 2,58,000 or 2,42,000 according to the specifications and rates finally elected for.

The upper earthen dams.

66. A detailed estimate for one of the three earthen dams has been got out in the rough and the cost is 49,625 rupees for work, according to the following specification.

The length of the dam at top is 1,300 feet the site being below the village of Maligal.

The breadth at top to be $\frac{1}{3}$ the height. The greatest height of dam is 55 and the greatest depth of water 50 feet. There is to be a puddle wall and trench, the breadth of the former at ground level, being one-third the height. The slope of puddle wall above ground to be 1 in 12 and below 1 in 8. The puddle trench to be carried down 8 feet throughout.

The natural ground surface to be excavated to a depth of $1\frac{1}{2}$ feet over the entire area, to be covered by the dam.

The water face to have a slope of 2 to 1 and the outer face one of $1\frac{1}{2}$ to 1.

The inner face to have a pitching of stone laid in mortar, and the outer face to be turfed with grass. The rate for puddle is taken at 12, and for ordinary earthwork 7 per 1,000 cubic feet as in the Hessarghatta project. If in lieu of these rates one of 17 per 1,000 for earthwork is allowed as in the Rachenhalli project, the estimate will be increased by approximately 30,000 rupees and the total will become approximately 80,000 rupees.

The slopes of 2 to 1 and $1\frac{1}{2}$ to 1 are those specified in the Rachenhalli estimate but the D. G. M. W. in criticising it indicated that it would be desirable to make the slopes flatter. At the Sankey tank the water face has a slope of 3 to 1 and the outer slope is 2 to 1; in the earthen dams in the Maligal valley it is proposed to adopt these latter slopes and this will further increase the estimate by some 30,000 rupees and make it approximately 1,10,000. To this must be added the cost of a water tower or other arrangement for drawing off the water to feed the lowest lake as required, say 10,000, which brings the estimate up to 1,20,000. Roughly speaking the cost of the earthen dam below the Maligal village will vary from 80,000 to 1,20,000 rupees according as Hessarghatta or Rachenhalli, rates for earthwork are found necessary. A suitable site for a second earthen dam will be in the vicinity of the bridge on the Magadi road, and for the third a spot will be

selected close to where the two main ravines meet below the village of Laggere The cost of each of these dams will be assumed the same as that below Maligal

When the four lakes formed by the masonry dam at Nagarbhavi, and the three earthen dams above are full, water should be continuous from end to end; but as it is drawn off, and wastage by evaporation, etc., occurs, the margins will recede, and the upper portion of each lake will become dry. In order to have as little loss as possible, when running water from an upper lake into one lower in the series, it is proposed to make provision for a length of one mile of masonry connecting channel. This need be of small section only and a rate of 3 Rs. per foot should suffice. The cost of this service would therefore be about 15,000 rupees. For each of the 3 waste weirs a sum of 10,000 is provided

The cost of the four lakes proposed in the Maligal valley will then be as under, according as Hessarghatta or Rachenhalli rates for earthwork are adopted, namely :—

	Rs.
1 Dam at Nagarbhavi	2,42,000
3 Dams above at 90,000	2,70,000
1 Mile of masonry connecting channel ..	15,000
Total....	5,27,000
say	5,30,000

or

1 Dam at Nagarbhavi	2,58,000
3 Dams above at 1,30,000	3,90,000
1 Mile masonry connecting channel ..	15,000
Total....	6,63,000
say	6,65,000

The take off arrangements.

67. The arrangement proposed, for drawing water off from the lowest lake of the series has been described in outline in paragraph 87 of the former report and sheet VIII of the drawings which accompany it. The design has not yet been worked out in detail but the sum originally provided i. e., 25,000 would seem insufficient and is now doubled.

Regulating well.

68. For the regulating well a sum of 3,000 is now entered instead of 2,000 as before.

Filter Beds.

69. In the former report the sum of 24,252 rupees was allowed for filtering tanks. This was the total of the detailed estimate for that item in the Rachenhalli scheme got out by Mr. deWinton. Three filter beds were provided, each measuring 100′×45′ or 4,500 square feet, any two of which working together would be capable of passing the then required quantity of water, namely 1,07,000 cubic feet in the 24 hours. The area of the filters was arrived at by considering that according to the best authorities on the subject the rate of filteration through a filter bed should not exceed 6 lineal inches per hour with a maximum depth on the filter bed of 2 feet.

In the joint scheme now under consideration the quantity of water to be passed daily through the filters is 2,00,000×10=20,00,000 gallons=3,20,000 cubic feet. Roughly speaking therefore the filters will need to be three times the size of those in the Rachanhalli detailed estimate, that is to say that three beds, will be required, each measuring 13,500 square feet. Two of these would always be working while the third would be in reserve. The filtering materials were 5 feet deep and consisted of sand and broken stone in the order shewn on the detailed drawings accompanying the estimate. They were to be surrounded by a compound wall to keep out intruders. The walls of the filters were vertical with offsets at intervals giving a mean thickness of masonry of about 3 feet and the rate per square foot of filter bed worked out to $\frac{24}{3}\times\frac{252}{4500} = 1{\cdot}87$ rupees nearly.

The cost of the three beds required in the joint scheme will at this rate be 3×13,500×1·87= 75,735 say 76,000 rupees.

In the Hessarghatta project the cost of three filters for filtering one day's supply of 5,00,000 cubic feet of water in the 24 hours is put down at 31,317 rupees. The cost of these filters in the Hessarghatta scheme with the reduced supply recommended by the Chief Engineer, Mysore, of 10 gallons a head for 200·000 people is shown as 25,000 rupees In the Hessarghatta project two of the three filters working together are to filter the day's supply at the rate of 75 gallons per square foot in 21 hours; the filtering strata to consist of sand, charcoal and stone jelly. The design consists in excavating the tanks with sides sloping at 1 to 1 and lining them and the floors with 1½ feet of brick in chunam plastered with Surki mortar In Mr deWinton's detailed estimate for the Rachenhalli filters the floors were to be of slab stones resting on a concrete foundation, and the joints in the floors and in the vertical stone walls were to be pointed in Portland cement Pending a settlement of the question as to which of the two designs and proposals is to be adopted, it will suffice to say here, that the cost of the filters in the Maligal joint scheme will be something between the 25,000 rupees shewn in the Hessarghatta project and 76,000 rupees worked out as above according to Rachenhalli data

Clear Water Tank

70. From the filters the water is to pass into a clear water tank from which it is to be pumped into service Reservoirs located at the upper extremity of the Rising Main As explained in paragraph 89 of the former report the size of this clear water tank need not be greater than to contain a day's supply The cost of the tank for the Civil and Military Station only, was put down at 11,000 rupees, that is to say, one half the cost, of a 2 day's supply, receiving tank, as worked out in detail by Mr deWinton, in the Rachenhalli scheme. The clear water tank formerly proposed at Nagarbhavi was to hold 120,000 cubic feet, but as one day's supply in the present proposals means 320,000 cubic feet the capacity of the tank will be taken at 360,000 cubic feet and the cost according to Rachenhalli data may be assumed at about 12,000 rupees If the Hessarghatta type of sloping sides be adopted the cost will be reduced to approximately Rs 20.000

Engine and boiler House and quarters for establishment

71. The cost of the engine and boiler house, with chimney and the quarters for establishment all of which will be erected near Nagarbhavi will be assumed the same as in the Hessarghatta project namely 20,000 and 16,000 rupees respectively instead of 17,000 and 11,000 as originally entered in the former Maligal report

Cost of take off filtering &c, arrangements at Nagarbhavi

72 The cost of the take off, filtering, &c, arrangements in the vicinity of the Nagarbhavi lake will then be as follows according as Hessarghatta or Rachenhalli specifications are elected for, namely

		Rs
Tunnel off take		50,000
Regulating Well	.. .	3,000
Filter Beds	.	25,000
Clear Water Tank		20,000
Engine and Boiler House with chimney	. ..	20,000
Quarters for Establishment	. .	16,000
	Total	. 134,000

or

Tunnel off take	. ..	50,000
Regulating well	..	3,000
Filter Beds	. ..	75,000
Clear Water Tank	. ..	42,000
Engine and Boiler House with chimney	..	20 000
Quarters for Establishment	. ..	16,000
Total		206,000

Pumps and Engines

73. The general level of the trap rock in the bed of the stream near Nagarbhavi on which the masonry dam is to be built is M S L 2,677 and the floor of the highest of the two

service Reservoirs the proposals in connection with which will be described later on; averages 3,070. From the former must be deducted say 10 feet, for loss of height in filtering, &c., and to the former will be added 10 feet for top surface of water, in Reservoir, so that the total static lift (making no deduction for vertical lift by suction) becomes 3080—2667=413 feet or say in round numbers 420 feet. The length of rising main from pumps to service Reservoirs is 4 miles 390 yards=22,290 feet. The quantity of water to be pumped up daily, is 320,000 cubic feet. If pumping is assumed to go on for 12 hours daily except Sundays the quantity to be raised per minute will be 444 cubic feet; and if, in accordance with the rule in Molesworth's Pocket Book, the velocity in the pumping main, is to be kept within 3 feet per second, a 24 inch pipe will be required. Such a pipe will discharge 452 cubic feet a minute with a velocity of 2·4 feet per second and a friction head of 1·14 feet per 1,000 feet.

The total lift will therefore be as under :—

Static Lift'	420′
Add for friction through main 22·290×1·14=25·4 say	26
Total.....	446
or in round numbers say	450 feet.

Then Nominal H. P. required $= \frac{444 \times 62 \times 450}{33{\cdot}000} = 376.$

In the Hessarghatta Project for the supply of 500,000 cubic feet a day to a height of 374 feet through $1\frac{3}{4}$ miles of 24 inch rising main N. H. P. required $= \frac{618 \times 62 \times 374}{33{,}000} = 435.$

The Agent of the Worthington Company quoted £19,500 for two triple expansion Engines each capable of delivering 618 cubic feet a minute against 374 feet head with four Babcock boilers; the whole plant complete, delivered, erected, and started to work at Bangalore. This sum taking the rupee at 1-2-0, is equivalent to 334,285 rupees. Owing to the considerably reduced H. P. needed in the Maligal scheme, it will, it is thought, be safe to put down the cost of the pumping plant there at 3 lakhs of rupees. In the Hassarghatta project the allowance is 2 lakhs only, for a delivery of 618 cubic feet a minute as above, but that entry was made prior to receipt of the Worthington tender. I understand that at Hessarghatta, it is in contemplation to pump 24 hours daily; and with two sets of engines, and three sets of establishment this would be possible. The power of the pumps, and their cost would of course come down handsomely. This is one of the points that needs decision, but clearly what is decided in the one case, will apply equally to the other. The cost of the plant at Maligal will therefore be assumed at 2 lakhs or three lakhs according to the power of the pumps eventually decided on.

The Rising Main.

74. As explained in the preceding paragraph, the diameter of the rising main must be 24 inches, if it be decided that the velocity is to be kept well below the 3 foot per second limit. In the Hassarghatta Project the delivery is 618 cubic feet a minute and the 24 inch pipe therein proposed would only effect this with a velocity of 3·2 to 3·3 feet per second and a friction head of 2 feet per 1000, as compared with the velocity of 2·4 feet per second, and friction head of 1·14 feet per 1,000 in the Maligal scheme. If the Hessarghatta data were accepted in the latter, the diameter of the pipe might be reduced to 22 inches or possibly even to 20 inches. But to diminish the pipe diameter too much would be clearly bad policy for it would mean throwing extra strain on the engines and allowing nothing for expansion of the supply. It seems pretty evident, that a rising main of less than 24 inches diameter would not be suitable in any combined scheme for the supply of both towns; and that dimension of pipe will be adhered to here. According to the Hassarghatta project the cost of the 22,290 feet of 24 inch rising main needed, in the Maligal scheme would be as follows :—

22,290 × (2·37 cwt. per foot run) × 7/12 per cwt. =	4,09,417
Laying 22,290 feet at 1 rupee ... =	22,290
Total	4,31,707

In November 1890 Messrs. Richardson and Cruddas tendered for the carriage, of 24″ pipes from railway station, excavation of trenches, and laying pipes, in the same, inclusive of lead jointing, at 1/12 per running foot. Recently however their tender for merely laying and jointing 1/12 inch piping for the Hebbal temporary scheme was exclusive of carriage and trench excavation 20 per ton which works out to about 1 per foot run. As the rising main in a permanent scheme, would be laid leisurely and tenders would be called for in the ordinary manner it is possible that a rate of 1 per foot for 24″ piping might suffice, but considering the distance it will have to be carried especially at Hessarghatta, a rate of 2 per foot run would seem safer. In this case the cost of the main in the Maligal scheme would be 453,997 rupees instead of 431,707 according to the Hessarghatta data, or say 456,000 to provide for air, scour and other special valves and fittings.

The service reservoir.

75. In the Maligal scheme, for the Civil and Military Station, only, the proposal was, to build the service reservoir on the piece of the High ground opposite the West End Hotel. This idea is now abandoned, and it is proposed to locate the reservoirs, for both the towns, on the bare, flat rocky hill situated immediately north of the village of Khetmarenhalli. The summit of this hill is at M. S. L. 3077, but it consists of two, nearly level, plateaus, of average heights, 3070 and 3055 respectively. There is room for a 7 days service reservoir for the Civil and Military Station on the upper and for a similar reservoir for the Pettah on the lower plateau. This hill is eminently adapted to the purpose to which it is proposed to put it and has the distinct advantage of greatly decreasing the length of pumping main.

A detailed estimate of the cost of the service reservoirs on this hill has been got out in the rough and it amounts to Rs. 1,50,000. It will not be possible on this site to adopt the system of excavating a tank with sloping sides as specified in the Hessarghatta project. On the other hand in that project provision is made for a 3 days service reservoir only, and if that principle be accepted at Hessarghatta it can be adopted at Maligal. Consequently the cost of the service reservoirs in the latter will be from 75,000 to 150,000 according to the dimensions decided on. Stone can be quarried from the lower portion of the hill, and the fact that the walls will for the most part rest on rock and that rock is very soon come to all over the site, accounts for the smallness of the estimate.

Town Distribution

76. In the former Maligal report, and in Captain Ward's Hebbal report, the rates for distributing 6¼ gallons of water per head, per diem, varied from 3½ to 3¾ rupees per individual. In the Hessarghatta project, the same rate is adopted but the quantity to be distributed is doubled. This does not seem right, as the average diameter of the pipes would necessarily have to be increased. Moreover it would appear that due allowance has not been made for the fact that the water will be consumed in a portion say ⅓ to ½ of the 24 hours. It will be, on the safe side to allow 4/4 a head for the distribution of the 10 gallon allowance to 2,00,000 people in the present scheme, *i. e.* 8½ lakhs of rupees instead of 7,60,000 as in the Hessarghatta scheme.

Compensation.

77. A detailed estimate of the probable cost of buying up, the 10 square miles of the Maligal catchment, has been prepared by the Superintendent of the Mysore Revenue Survey, and it aggregates to 2½ lakhs of rupees. In the Hessarghatta project, the provision for compensation amounts to only 2,20,000 but it extends, merely to the value of the tanks, themselves, and the stoppage of wet cultivation below the bunds. In paragraph 42, Part IV of this report the result was given of an analysis of the Hessarghatta water carried out by the Chemical Examiner, Madras. It was declared to be "suspicious." The following is an analysis, by the same authority, of specimens of water, taken from pools in the ravine in the Maligal valley below the village of Laggere referred to in paragraph 45 of this report the specimens were taken by me with the usual precautions in the morning of the 2nd March and despatched to Madras the same evening.

The specimens were taken by me with the usual precautions in the morning of the 2nd March and despatched to Madras the same evening.

		Sample of water from Maligal river Bangalore.
Total Solids ...	... Grms. per litre ...	... 0·420
Volatile Solids	... do ...	... 0·100
Chlorine ...	... do ...	... 0·088
Total hardness ...	... Clark's scale ...	... 7°·000
Permanent hardness	... do ...	... 0°·350
Free Ammonia ...	... Ml grms. per litre ...	... 0·040
Albumenoid Ammonia	... do do ...	... 0·080
Nitric Acid	... do do (as ammonia)...	0·240
Apparent quality of the water as inferred from the results obtained on examination.		Usable.

Remarks—The chlorides are higher than in an usable water, but I do not attach much importance to this, as the ammonias are well under the limits of safety. Care must however be taken to exclude possibility of pollution.

(Sd). J. L. VAN-GEYZEL, SURGEON MAJOR,

Chemical Examiner, Madras.

As the specimens were taken from a very shallow stream, the water in which is liable to pollution from passing cattle etc, it will, it is thought, be allowed that the test was sufficiently severe and the result satisfactory. But it may fairly be assumed, in view of the bareness of the valley, and its freedom from villages, and cultivation, that the character of the water, behind 50 and 60 feet dams will be vastly superior to that evidenced by the foregoing analysis. The Sanitary Commissioner of Madras wrote as follows in his No. 0—1 of 10th April 1889 to the Secretary to the Government of Madras, Public Works Department, "*The scheme therefore which I would recommend is the Magadi Road one, as from a sanitary point of view it undoubtedly would give purer water than either the Hebbal or Dhasarhalli (Rachenhalli).*

Reference has been made here to the analysis of the water from the two localities of Hessarghatta and the Maligal River, merely in support of the view that if in the former, conservation requirements will be met, by simply stopping wet cultivation, below tanks and preventing people from bathing or washing their clothes or cattle in them, it will be quite unnecessary to go farther than that in the latter, the compensation charges in which would then be enormously reduced. For compensation in the Maligal valley therefore the expenditure will, it is here assumed, vary from say Rs. 50,000 to 2,50,000 according to the nature of the precautions taken to prevent pollution and ensure purity of supply.

Establishment, tools and plant etc,

78. For establishment, tools and plant the usual allowance will be made of 24½ per cent on all items representing work, and in addition to 5 per cent for contingencies, Colonel Mc Neil Campbell's precaution of adding a lump sum for unforeseen expenses will be followed.

79. The details of expenditure discussed in the preceding paragraphs are brought together in the following abstract, which shews, what the cost of a combined scheme will be with the Maligal valley as a basis.

I. According to the specifications and data adopted in the Hessarghatta project.

II. According to the specifications and data adopted heretofore, and embodied in the detailed Rachenhalli project for the Civil and Military Station worked out by Mr. deWinton.

MALIGAL VALLEY COMBINED SCHEME.

FOR 2,00,000 PEOPLE AT 10 GALLONS A HEAD PER DIEM.

	According to Hessarghatta Data and specifications.	According to Data and specifications formerly accepted.	Remarks.
Masonry and Earthen Dams in the Maligal Valley	5,30,000	6,65,000	
Off take, filtering etc., at Nargarbhavi..	1,34,000	2,06,000	Includes in each case Engine House and qrs. for establishment.
Pumps and Engines	2,00,000	3,00,000	
Rising Main	4,31,707	4,56,000	24" Pipe in each case.
Service Reservoir	75,000	1,50,000	3 days in the one case, 7 in the other.
Distribution	7,60,000	8,50,000	
Total	21,00,707	26,27,000	
Contingencies 5 per cent... ..	1,06,535	1,31,350	
Establishment, Tools Plant ...	2,09,430	2,50,145	
	24,46,672	30,08,495	
Compensation	50,000	2,50,000	For land submerged in the one case for purchase of catchment in the other.
Unforeseen charges	1,00,000	1,00,000	
Grand Total...	25,96,672	33,58,495	
Say...	26 lakhs.	Say . 34 lakhs.	

80. The case for the Maligal valley as the basis of a joint scheme is :—

The case for the Maligal valley as the basis of a joint scheme.

(1) That the quality of the water is by universal consent, admitted to be better than that obtainable in any other catchment.

(2) That owing to the steepness and bareness of the hills, the natural catchment of 10 square miles will probably give a sufficient quantity of water.

(3) That if it does not, it can be doubled at no prohibitive outlay the areas added consisting of the highest, cleanest and little cultivated portions of adjoining catchments.

81. Prior to moving on to the last section of this report, it will, it is thought, be convenient to say something about the cost of a scheme for the Civil and Military Station alone; with the Maligal valley as its basis, in the event of difficulties arising, in the direction of a joint undertaking. A perusal of the present report will have made it clear that the cost of the single scheme will be considerably less than it was thought safe to assume it might be, when the former report was drawn up nearly a year ago..

Cost of Maligal valley project for the C. and M Station alone.

For the supply of 10 gallons a head per diem to say 100,000 persons in the Civil and Military Station only, the following modifications would be admissible in connection with the foregoing proposals for a joint scheme. A single lake with dam at Nagarbhavi would probably suffice, but in any case a single earthen dam above this lake, instead of three would only be needed. The power of the pumps and engines would of course be reduced The filtering, &c., arrangements at Nagarbhavi would be on a smaller scale.

The diameter of the rising main might be reduced to possibly 14 inches and certainly to 18 inches.

The size of the Service Reservoir would be about one-half of what is needed in a joint scheme, and finally the scope of the town distribution would be much less. In terms of these modifications the annexed abstract shews the alternative approximate cost of a Maligal valley scheme for the Civil and Military Station only, according, as before, to which set of data and specifications sanction is accorded.

MALIGAL VALLEY SCHEME.

FOR 100,000 PEOPLE IN THE CIVIL AND MILITARY STATION AT 10 GALLONS PER HEAD PER DIEM.

	According to Hessarghatta data and specifications.	According to the data and specifications formerly accepted.	Remarks.
Masonry and earthen dams ...	3,37,000	3,93,000	Includes in each case engine house and quarters for establishment.
Off take, filtering, &c., at Nagarbhavi.	1,15,000	1,63,000	
Pumps and engines	1,00,000	1,50,000	
Rising main	2,95,000	3,05,000	18" pipe in each case.
Service Reservoir	40,000	75,000	3 days in one case 7 days in the other.
Distribution	3,80,000	4,25,000	
Total.....	12,67,000	15,11,000	
Contingencies 5 per cent ...	63,350	75,550	
Establishment, tools, plant ...	1,20,500	1,54,700	
Total.....	14,50,850	17,41,250	
Compensation	30,000	2,50,000	For land submerged in the one case, for purchase of catchment in the other.
Unforeseen charges	50,000	50,000	
Grand total.....	15,30,850	20,51,250	
Say.....	15½ lakhs	Say 20 lakhs	

Result of rain fall on March 5th, 16th in the Maligal valley.

82. In concluding this section of the report it may be noted that the rain last week *i. e.*, on March 15th and 16th sufficed for a stream of water between 4 and 5 feet deep to pour over the reef of trap rock in the bed of the stream at Nagarbhavi.

The fact of a moderate fall of rain in the height of a season of drought, lasting many months, having caused such a flow of water in the Maligal stream demonstrates satisfactorily it is thought, that Mr. de Winton's anticipations (see paragraphs 46—48) are probably not far out and that the figures adopted for run off now, in this valley are well within the limits of safety.

PART VI.

GENERAL CONCLUSIONS.

Question of the number of people to be supplied and the allowance per head per diem.

83. Within the last few days, and subsequent to the completion of Part IV of this report I have had the advantage of a perusal of the Dewan's Note on the Hessarghatta joint scheme from which I see that he adheres to the view, that its scope, should not be limited to 10 gallons a head for 2,00,000 people, as recommended by the Chief Engineer and

Secretary to Government, Mysore, Public Works Department; but should extend to the supply of 2,50,000 individuals at an allowance of 2 cubic feet or 12½ gallons In paragraph 51, Part V, it was observed that as the population at present is only 1,80,000 and former proposals had only run to 6¼ gallons a head; to provide for an increase of population further than 10 gallons for 2,00,000 people would be equivalent to the present generation paying for the benefit of its successors, an arrangement, in which, looking to the existing financial crisis and the claims of other towns; it would if was thought, be difficult for the Government of India to participate. The principle advocated throughout this report has been to adopt a scheme which although not necessarily complete in itself, will admit of ready extension, from time to time, without extensive dislocation of what has gone before. In the reduced scheme, Colonel Mc Neil Campbell has allowed for Rising and Delivery Mains of 20 inch diameter instead of 24″ in the bigger scheme. In paragraph 74 it has been argued, that although such a pipe might answer at present, with a high velocity it would admit of no expansion, and it was accordingly urged; that in no scheme for a joint supply, should the diameter of the main pipe be less than 24 inches. With such a sized pipe, water sufficient to meet present requirements, could be pumped up at a moderate velocity and both pumps and pipes would have a reserve available for increasing demands. Although Colonel Campbell has mentioned a 20 inch pipe to shew how economy could be effected; I do not gather that he actually recommends its adoption and under these circumstances it would seem that on this important point, there is in reality no divergence of opinion between the views expressed by Sir Sheshadri Iyer, the recommendations of Colonel McNeil Campbell, and the principle advocated by me. Again, whereas the Hessarghatta Project provides a service Reservoir of a capacity sufficient for 3 days supply of 2,50,000 people at 12½ gallons a head equivalent to 1½ Million cubic feet; the proposal herein made is to make this reservoir sufficiently large for the 7 days supply of 2,00,000 people at 10 gallons a head equivalent to 2¼ Million cubic feet nearly. Here again therefore there is no real divergence of opinion. The allowance of 10 gallons is certainly small compared with that enjoyed by other large towns elsewhere but it is difficult to lay down a hard and fast rule for an allowance of this kind. A town like Bangalore situated on the high part of a plateau, above surrounding plains can hardly expect to get as adequate a supply as another, lying near the foot of mountains, in which there is a superabundant amount of water. Experience shows, that with increased facilities for obtaining water, the demand also increases, and in the latter of the two cases mentioned above, there would be no reason, why the system of distribution should not make due allowance for the complete water requirements of the station. But in the other case of a town like Bangalore, it seems a matter for consideration, whether it will not be judicious—at the start at all events—to considerably curtail the system of distribution. The principle might be this; that while the distance of stand posts and the facilities for drawing water, should be so regulated, as to make it worth everyone's while to use the good water for drinking and culinary purposes, the use of the existing tanks, for the watering of horses and cattle, for building, and possibly to a certain extent for bathing purposes, should continue. The cost of bringing in to Bangalore at one sitting a supply of really pure water, which of itself shall be sufficient for requirements of all kinds, would seem to be quite prohibitive—though steps in that direction might well be taken later on.

The crying want at Bangalore to begin with is a sufficient supply of really good drinking water.

84. The following is a summary of the conclusions come to in Parts II to V of this report.

Summary of conclusions in Parts II to V.

(1). That the advantages of Rachenhalli over Hebbal as the basis of a water supply scheme are for the reasons specified in Part III self evident.

(2). That neither in respect to "*quality*" or "*quantity*" of the supply is there any object in going 11 miles as the crow flies to Hessarghatta instead of 4 to Rachenhalli.

(3) That as regards "*quality*" the Maligal valley is far the best source and that owing to the nature of the catchment the "*quantity*" will in all probability be sufficient also. That in any case the catchment can be increased to whatever extent may be found necessary the areas thereby included, approximating, in respect to cleanliness to that of the natural catchment.

See para 82.

85. With respect to Hebbal little more need, it is thought, be said here. It has these advantages over the other three—A lift some 40 feet less than Rachenhalli, and some 200 feet less than Maligal or Hessarghatta—A length of approach to the Service Reservoirs of about two miles against about 4 at Rachenhalli and Maligal and over 13 at Hessarghatta. But the catchment can only be extended at considerable outlay and the character of the water is distinctly inferior. As regards this latter point the analysis shews it to be much the same as water from Rachenhalli and Hessarghatta, but no one can fail to be struck by its muddy red color which is quite distinct from that of the other tanks. It contains as stated by the chemical examiner, Madras "*a large amount of very fine clay and sand which passess through even a fine filter. Precipitation in a settling tank before filteration is advisable.*" The fact of there being in existence so close to Bangalore a fine looking sheet of water leads to its being considered by many as the natural source of supply, but when we go under the surface and examine the question carefully in all its bearings, the advantages enumerated above are, it is thought, swept away by its serious defects more especially of quality.

The disadvantages of Hebbal far outweigh the advantages.

86. Relative to 'Rachenhalli' and "Hessarghatta" much more must be written, notwithstanding my earnest desire to bring this long report to a finish. First as regards "quality" it was stated in paragraph 42 that the analysis shewed "Hessarghatta" water to be no better than Rachenhalli; but to compare the waters in these two particular tanks as they now exist is I think, for reasons which will now be given, hardly fair to the Rachenhalli scheme.—This scheme takes its name from the tank of that name, but the main feeder in a joint scheme with this locality as its basis, would be the Yellahanka tank.—On the 10th of this month a very careful examination of this portion of the catchment was made, beginning at the Rachenhalli bund, round the margin of the tank, up to the bund of the Jakkur tank, round that tank, and up to the Yellahanka dam.—The Rachenhalli tank is very shallow, and but for the loss of gathering ground and the greater length of Rising Main, is not so well suited for water supply as the Jakkur.—Between Yellahanka and Jakkur, and Jakkur and Rachenhalli, there is a great deal of wet cultivation, all of which would necessarily cease if the tanks were taken up for a water-supply. Instead therefore of comparing Rachenhalli and Hessarghatta water, it seemed that a better forecaste would result, by substituting water from Yellahanka. Specimens of the latter were accordingly taken in the usual manner and despatched by mail train the same evening to Madras, for analysis. The result thereof is given below:—

Rachenhalli versus Hessarghatta in respect to *quality* of supply.

		Sample of water from Yellahanka Tank.
Total Solids ...	... Grms. per litre ...	... 0·180
Volatile Solids ...	... do do ...	... 0·060
Chlorine ...	... do do ...	... 0 021
Total Hardness . .	... Clark's scale ...	... 2°·450
Permanent Hardness	... do do .	... 0°·700
Free Ammonia ...	... Ml grms. per litre ...	... 0 040
Albumenoid Ammonia	... do do ...	. 0·320
Nitric Acid ...	. do do (as ammonia)...	0 240
Apparent quality of the water as inferred from results obtained on examination.		Usable.

Remarks.—Sediment slight, consisting of sand and vegetable debris.

(Sd). J. L VAN GEYZEL, SURJEON-MAJOR,
Chemical Examiner, Madras.

This is a distinct improvement on Rachenhalli or Hessarghatta and is not surprising looking to the directness and cleanliness of large tracts of the Yellahanka gathering ground on the north. After buying up the catchment and prohibition of cultivation, removal of villages etc, the quality of the water in the Rachenhalli tank should assimilate to that of Yellahanka which would of course improve. So far then as "quality" is concerned the correctness of the view that it is useless to go to Hessarghatta instead of Rachenhalli has, it is submitted, been established.

Relative to "quantity."

87. Next as regards "quantity." It was argued in paragraph 40, that the difference between 50 square miles of catchment at Rachenhalli and 211 at Hessarghatta would only be of some importance from a water-supply point of view, if a catchment of over 50 square miles is ever likely to be needed for Bangalore, and the conclusion come to, was, that such was not likely to be the case for many decades to come; and that when the necessity did arise, the area could be extended. Let us go now a little more closely into this matter and see what the proposals, in respect to the catchment of 211 square miles at Hessarghatta really amount to. Out of the 183 tanks in this gathering ground, it is proposed to take up for the water-supply scheme, some 8 to 12 only, and thereby to get an available catchment of some 30 square miles, with a storage capacity of 884 millions of cubic feet. Years of very good fall are not apparently taken into special account and the run off, calculated upon, is so small that in bad years, it is not expected that the tanks will receive much more than a tenth of their total capacity. In an average year even, it is not expected that they will fill, and indent is then to be made on the remainder of the catchment 211—30=181 square miles to make up the deficiency. The conservation of the catchment of 30 square miles of the tanks to be actually taken up, is to be limited to throwing out of cultivation the wet land below, and preventing the inhabitants washing themselves, their clothes or their beasts in them. For the conservation of the remainder of the 183 tanks nothing is proposed, and clearly nothing would be financially possible. Provided that steps are taken to ensure the water from the upper tanks finding its way into the lower, the quantity will be inexhaustible, but on its quality no dependence can be placed. Moreover, the question arises, what becomes of this water, at ordinary times? Does it run to waste or is it utilised? If the latter, will not compensation be needed when it is appropriated for water-supply purposes?

In all schemes that have been considered heretofore, the practice has been, to calculate what area of catchment is needed to give the required run off, and then to have that area thoroughly conserved. The calculations as to area have been more or less based on Mysore data for run off which varies from 15 to 18 per cent. Mr. deWinton as noted in paragraph 16 of this report and Colonel Campbell in paragraph 25 of his note on the Hessarghatta project observe that these calculations are erroneous because with greater rain fall, there should be greater run off. Mr. deWinton therefore in his estimate for the Civil and Military Station with Rachenhalli as the basis, allowed runs off as under, per square mile of catchment.

6 Million cubic feet in a year of bad fall of 17″
10 Million cubic feet in an average year.
14 Million cubic feet in a good year.

For the reasons adduced in paragraph 21 of this report I assumed for a catchment like Hebbal or Rachenhalli.

In a bad year 6 M. cubic feet instead of 7 according to Mysore data.
In an average 12 M. cubic feet „ 11 „ „
In a good 20 M. cubic feet „ 17 „ „

and accordingly arrived at the conclusion that in such a catchment, an area of about 20 square miles would be needed for the water-supply of the two towns.

In the Hessarghatta proposals an entirely new departure is taken, and it is assumed that an area sufficient of itself, cannot be obtained, and that indent must be made on a long chain of tanks lying outside of it, to supplement the deficiency. In paragraph 26 of his note, Colonel McNair Campbell puts the run off in the Hessarghatta catchment at 8 per cent only, in a year of minimum fall

of 17 inches equivalent to 3·15 Million cubic feet per mile, instead of 6 as assumed by Mr. deWinton and myself at Rachenhalli, or 7 as should be allowed according to Mysore data. The conclusion to which one must come then is, either that the prospects of a run off in the Hessarghatta catchment are exceptionally bad; or else that they have been under estimated. Since the run off from Kakol one of the tanks to be taken up, (see the end of paragraph 27 of Colonel Campbell's report) was 11 Million cubic feet per square mile, with rain fall below the average, and since in 1892 (see the same paragraph) with a rain fall of 27 inches the run off of an almost wholly artificial catchment like Sankeys, was also 11 Million cubic feet per mile, it seems that the forecaste of run off is somewhat pessimistic. It is a question whether in either catchment Hessarghatta or Rachenhalli, runs off of 6, 12 and 20 Million C. ft. are not below instead of above what may fairly be expected. It is only natural with the experience of the insufficiency of the Sankey tank gathering ground, before their eyes, that Engineers should be very cautious in proposals for the catchment areas of a new scheme, but the danger of falling into the opposite extreme would equally seem to need guarding against. Turning to the report submitted by Mr. O'Shaughnessy in September 1891, I find that the total catchment area of the existing Civil and Military Station supplies, is put down at 8·8 square miles inclusive of the 2½ square miles of for the most part artificial catchment of Sankey's. The rest of the catchment is chiefly covered by streets, houses and drains, all of which tend to absorb rain-fall and prevent a free run off. The supply in Sankey's has been partly given to the Pettah. This is the second of a series of bad years and as the Dewan says, a third year of drought is one of which there is no experience and which may safely be left out of consideration. These 8·8 square miles are the gathering ground of the entire water-supply for some 1,00,000 people in the Civil and Military Station including all requirements, washing, drinking, horses, cattle and building. It has not yet actually failed, and the fact of things being so bad as to necessitate arrangements being made for pumping from Hebbal is partly accounted for, I have heard it said, owing to a large quantity of water which ought to have found its way through the main feeder to the Ulsoor tank having taken a wrong turn and visited the main sewer instead. If 8 to 9 square miles of most unfavorable catchment have sufficed for all these years for 1,00,000 people, it is not unreasonable to assume that from 20 to 30 square miles of catchment specially set apart for the purpose at Rachenhalli or Hessarghatta or 10 square miles of a catchment like that of the Maligal valley should meet the most important requirements of a population of 2,00,000; supplemented as it is urged, they must be, to begin with in a situation like this, by the existing supplies for horses, cattle and building.

If the quality of the water is an all important consideration it seems evident that the gathering ground must be carefully conserved, and that from the nature of both the Hessarghatta and Rachenhalli catchments heavy expenditure on that account must be incurred. If the supply of as pure a water as possible is not the mark aimed at, then it will be for consideration whether all heavy expenditure may not be avoided by simply increasing the areas of the existing impure catchments: If expensive pumping plant and long lines of piping are to be imported the water to be passed through them should be superior in quality to what passes muster at present: If therefore quality and quantity are to walk hand in hand a clear case has it is submitted been made out in favor of Rachenhalli as compared with Hessarghatta. It is only when the quality is wanting, as it is thought, it would certainly be, in the absence of proper and consequently costly conservation, that the 211 square miles at Hessarghatta would have any advantage over the smaller catchment at Rachenhalli.

Put briefly, the situation as regards both these catchments is, it is thought, this—that looking to the nature of the country and the slopes a gathering ground of some 20 square miles should suffice, and to ensure purity of supply it is essential for this area to be perfectly conserved:

Relative cost of the Hessarghatta and Rachenhalli schemes

88. Turning next to the question of the relative cost of these two schemes it was urged in Part IV that other things being equal, a scheme based on a tank 4 miles distant from the Service Reservoir must be very much more costly

than on another 11 miles from the same objective. These two numbers of 4 and 11 do not however, give the actual relative distances. In the Rachenhalli Project the length of the rising main which would go nearly as the crow flies from the lake, to the Service Reservoir, on the Muntapum Hill, is actually a little less than 4 miles. In the Hessarghatta Project as worked out, with a view apparently, of getting over the expense, of an iron main of 11 miles, water from the lake is first conveyed downwards, in a winding masonry channel. This channel is continued, as far as the ground permits, in the direction of the Banavar Hill, and ends in a receiving Reservoir. Here the plant is to be located and the water is to be pumped through a cast iron main, to the top of the hill. But as the hill is not of itself sufficiently high, to give the necessary command over a Service Reservoir with floor at only 3055 M. S. L., on the Muntapum Hill, distant some 7 miles, recourse is had to a stand pipe 42 feet high. Over this the water is to pass, and thence flow by gravity in an iron main to the Muntapum. In this way, the length of ground to be got over, before the Service Reservoir is reached is 13 miles 129 yards against 3 miles 1100 yards in the Rachenhalli, and 4 miles 390 yards in the Maligal Scheme. In paragraph 11, clause (2) of his note, the Dewan indicates the desirability of investigating whether water should not be pumped to the top of the Chik Bettahalli instead of the Banavar Hill; and inasmuch as the route to the Muntapum *via* the former would be sensibly reduced, I think there is no doubt that his view is correct. But although I have not had time to examine the country between Hessarghatta and Chik Bettahalli closely and cannot therefore speak with certainty, I am under the impression that a continuous iron pumping main would be necessary or would at all events, be as cheap as the heavy engineering works which would be the alternative. In either case, therefore, there would be either about 11 miles in all of piping, or over 13 miles of mixed piping and masonry channel, against less than 4 miles of main in the Rachenhalli Project.

89. Again, the lift at Rachenhalli, including friction in pipes, is 240 feet, and in the Hessarghatta project it is shewn to be 374 feet; but this allows, as already pointed out, for a Service Reservoir on the Muntapum Hill with floor at 3,055, instead of at about 20 feet higher as has been proposed heretofore. The highest parts of the Civil and Military Station are at 3.061, and the Muntapum Hill is about a mile distant. If the whole of the Station is to be commanded, and this would appear to be absolutely essential, it cannot be correct to fix the floor of the Service Reservoir a mile away, and six feet *lower* than the highest points. In the scheme for the supply of the Civil and Military Station, with the daily allowance of $6\frac{1}{4}$ gallons per head only, Mr. deWinton's calculations shew a loss of head by friction, of nearly 11 feet, between the Service Reservoir and the high ground. The Civil and Military Station has had a long and somewhat expensive experience of the inconvenience, resulting from a Service Reservoir, with an insufficient command. It is not clear why the level of 3,055 has been chosen, and it may, it is thought, be taken for granted that the higher level proposed in other projects will be substituted. This will necessitate a higher stand post, on the Banavar Hill, and heavier, and consequently more expensive pumping. For the Pettah, which lies so much lower than the Civil and Military Station as a rule, a Service Reservoir with floor at 3,055 feet would be quite suitable.

Ways in which the difference in cost between the Rachenhalli and Hessarghatta projects can be reduced.

90. There are only two ways, in which the great difference in cost between a Rachenhalli and a Hessarghatta scheme can be reduced; namely by paying much less for purchase, and conservation of land, and by adopting cheaper specifications for works. But the result of the analysis shews that if 7 lakhs need to be paid to ensure a clean catchment at Rachenhalli, that sum will equally be required at Hessarghatta for a corresponding area. As regards the specifications in the Hessarghatta project, endeavour has been made to avoid criticism as far as possible, and it is merely pointed out, that if they are approved they can also be adopted at Rachenhalli. There is therefore nothing in the circumstances at Hessarghatta to make up for the greatly increased cost involved by the two facts, of the length of approches being more than treble, and the height to be pumped, getting on for double, the corresponding length and height at Rachenhalli.

91. In dealing with the Maligal project, an abstract (see paragraph 79) was given, shewing the difference in cost of that project by adopting Hessarghatta data and those previously proposed. In order to make things clearer the abstracts which follow, have been prepared, to shew similarly, the approximate relative cost of projects at Hebbal, Rachenhalli and Hessarghatta.

Relative cost of Hebbal, Rachenhalli, Hessarghatta schemes.

HEBBAL COMBINED SCHEME.

FOR 200,000 PEOPLE AT 10 GALLONS A HEAD.

	According to the Hessarghatta Data and Specifications.	According to Data and Specifications formerly accepted.	Remarks.
Bund, surplus weirs etc.	1,50,000	2,00,000	
Pumps and Engines	75,000	1,30,000	
Rising Main	2,39,000	2.50,000	24" Main in each case.
Engine House etc.	20,000	20,000	
Grs. for Establishment	16,000	16,000	
Receiving Reservoir	30,000	80,000	
Filter Beds	25,000	76,000	
Service Reservoir	1,22,000	5,00,000	For 3 days supply in the one case for 7 in the other.
Compensation	See	below.	
Distribution	7,60,000	8,50,000	
Total...	14,37,000	21,22,000	
Contingencies 5 per cent	71,850	1,06,100	
Establishment, Tools, Plant ...	88,935	2,18,540	
	15,97,785	24,46,640	
Compensation	2,00,000	5,00,000	For stoppage of wet cultivation and purchase of tanks in the one case, for purchase of the catchment in the other.
Add for additional catchment ...	7,00,000	7,00,000	
Grand Total.....	24,97,785	36,46,640	
Say...	25 lakhs.	Say 36½ lakhs.	

NOTE RELATIVE TO SERVICE RESERVOIR.

The sum of 1,22,000 is that in paragraph 78 of Colonel Campbell's report, for a Reservoir of about 3 days capacity.

Mr. deWinton's detailed estimate for a 2 days Service Reservoir in the Rachenhalli Scheme amounted to Rs. 51,494, capacity 2,14,000 c. ft. For a 7 days Reservoir for 2,00,000 people at 10 Gallons a head the capacity needed is 2·24, M c. ft. and the cost work out to over 5 lakhs.

RACHENHALLI COMBINED SCHEME.

FOR 200,000 PEOPLE AT 10 GALLONS A HEAD.

	According to the Hessarghatta Data and Specifications.	According to the Data and Specifications formerly accepted.	Remarks.
Bund and Surplus weirs, etc. ...	1,50,000	2,00,000	
Pumps and Engines	1,00,000	1,50,000	
Rising Main	4,30,000	4,30,000	24" Main in each case.
Engine House, etc.	20,000	20,000	
Quarters for Establishment ...	16,000	16,000	
Receiving Reservoir	30,000	80,000	
Filter beds	25,000	76,000	
Service Reservoir	1,22,000	5,00,000	For 3 days supply in the one and for 7 days in the other case.
Compensation	See below.		
Distribution	7,60,000	8,50,000	
Total.. ..	16,53,000	23,42,000	
Contingencies 5 per cent	82,650	1,17,100	
Establishment, Tools, Plant ...	88,935	2,18,540	
Total	18,24,585	26,77,640	
Compensation	2,00,000	7,00,000	For stoppage of wet cultivation and purchase of tanks in the one case for purchase of catchment in the other.
Grand Total.....	20,24,585	33,77.640	
Say...	20¼ lakhs.	Say 34 lakhs	

NOTE RELATIVE TO SERVICE RESERVOIR.—See the Hebbal abstract above. The same remarks apply here. The area of Reservoir in Mr. deWinton's estimate amounting to Rs. 51,494 is 21,400 square feet and the rate is therefore 51-494÷21.400=2·46 per square foot.

Area now needed 2,24,000 square feet=at 2·46 to Rs. 5,51,040.

HESSARGHATTA COMBINED SCHEME.

FOR 200,000 PEOPLE AT 10 GALLONS A HEAD.

	According to the Hessarghatta Data and Specifications.	According to the Data and Specifications heretofore accepted.	Remarks.
Head Works	1,40,000	2,05,000	
Delivery channel	1,20,000	1,20,000	
Settling Tanks	20,000	80,000	
Pumps and Engines	1,80,000	2,80,000	
Rising Main	1,30,000	1,75,000	
Engine House	20,000	20,000	
Quarters for Establishment ...	16,000	16,000	
Stand Pipe	3,000	5,000	
Delivery Main	4,70,000	7,50,000	
Filtering Reservoir	25,000	76,000	
Service Reservoir	1,22,000	5,00,000	
Compensation	See below.		
Distribution	7,60,000	8,50,000	
Total...	20,16,000	30,77,000	
Contingencies 5 per cent	1,00,800	1,53,850	
Establishment, Tools, Plant ...	1,30,000	2,49,165	
Total .	22,46,800	34,80,015	
Compensation	2,20,000	10,70,000	
Unforeseen expenses	47,000	47,000	
Grand Total.....	25,13,800	45,97,015	
Say ..	25¼ lakhs.	say 46 lakhs	

NOTE RELATIVE TO SERVICE RESERVOIR.—See the note under the Hebbal and Rachenhalli abstracts which apply here also. The Hessarghatta rate is about 8 to 9 annas per foot. The Rachenhalli rate of nearly 2—8—0 includes lascars, quarters and a store room.

92. The statement below shews the relative cost of the several schemes according to the two alternative sets of data and specifications.

Relative cost of the four schemes.

Comparative statement of the cost of the several combined schemes.

	According to Hessarghatta data and specifications	According to data and specifications.
	Lakhs of rupees.	Lakhs of rupees.
Hebbal	25	36½
Rachanhalli	20¼	34
Hessargatta	25¼	46
Maligal	26	34

93. It remains to compare the Rachenhalli and the Maligal projects: Here, as before, the former has the distinct advantage of a lift of nearly one half the other, but unlike Hessarghatta the length of approach at Maligal is nearly the same as at Rachanhalli. Again, owing to the steepness and cleanliness of the Maligal catchment, it is believed that a much less area will suffice; and it is certain that the cost of taking up that area will be about ⅓rd that needed to buy up the necessary catchment at Rachenhalli. Further, in the matter of the Service Reservoir great economy should result by the adoption of the flat rocky site above Ketmarenhalli as proposed in the Maligal scheme instead of the Muntapum as is necessary in the Rachanhalli.

Comparison of the Rachanhalli and Maligal schemes.

See paragraph 82.

The result is that the cost of a Maligal scheme with its 10 square miles of steep and uncultivated catchment, will be approximately the same as a Yellahanka-Jakkur-Rachenhalli scheme with 20 square miles of comparatively flat and in many portions highly cultivated catchment. The Maligal catchment can, as has been fully explained in Part V, be doubled at a cost of 2½ lakhs; but this sum does not include the cost of actually buying up the added tracts. The Maligal catchment can be still further increased should that ever become necessary in a manner similar to that described in Part II for increasing the Hebbal catchment.

94. The choice of the best scheme for the joint supply of the Civil and Military Station and Pettah, appears to me to lie between Rachanhalli and Maligal, exactly as it did some 18 months ago, when the question of the supply of the former alone was under consideration. And the situations still further resemble each other in this respect, that Mr. de Winton was then, and I am now, convinced of the superior merits of Maligal over Rachenhalli. I am of the same opinion if the decision should after all, be in favor of separate schemes. If 20 square miles of the Rachenhalli catchment can be bought up so as to include the Yellahanka tank there is no doubt I think about the water being sufficient in quantity; and the result of the analysis of the water in that tank tends to shew that eventually when cultivation has stopped for some years and villages have ceased to exist the quality will greatly improve. Eventually no doubt the whole of the valley up to Rajankunta and Tarhunse, &c., would be taken up and become the gathering ground of the water supply of the Bangalore

Choice of best scheme lies between Rachenhalli and Maligal.

and Pettah of the future. But, as when nations go to war with each other, they send forward their best troops and only indent on their less trained reserves, when compelled to do so by losses and exhaustion; so it would seem in the present case should we first have recourse to a typical water supply catchment such as the Maligal valley; and only indent on irrigation catchments such as Hebbal and Rachanhalli when the resources of the former are exhausted. A decision to abandon in favor of irrigation catchments, a catchment of which the following things have been said, should not, it is thought, become to without very careful consideration.

By Mr. Standish Lee by whom in the prize essay of 1888 the value of the Maligal valley as a water gathering ground was first brought to notice.

" * * * *almost entirely composed of mountain pasture, scrub jungle and out crops of rock with a fine clean gravelly soil. Its head lies in the laterite formation alluded to as promoting springs * * * * * * * * * It has a limited stream of spring water flowing through it all the year round. It has none of the disadvantages of the others viz filth manured cultivated grounds, extensive inhabited areas, nor lands that will be deprived of their water-supply; there are no bunds higher up the valley to intercept the first flow of flood waters, nor riparian land owners lower down to claim compensation as the waters now run merely to swell the Arkavati."*

By Colonel Hasted R. E., when Chief Engineer, Madras, Public Works Department.

"The country here is very different in character to the Hebbal basin, the slope of the drainage is very much greater, high rocky mounds, with deep valleys between, break up the surface; and for the most part the land is waste; with a very small extent of dry cultivation, a few mere ponds, and a few very small villages. The run off must be very much greater than in the other valley and the poor character of the soil may be seen from Mr. Garratt's statement based on the authority of the Amildar of Bangalore, that to buy up about 5 square miles with all houses, trees, ponds and cultivated land would cost only Rs. 82,000. The ground is, as has been ascertained by inspection, eminently suited for a gathering ground; the valley is deep and very narrow in parts, and there are sites where it contracts below apparently fair sized basins, where reservoirs might be formed at very reasonable outlay. There is a little laterite to be seen at the head of the valley, but everywhere else the out cropping rock is igneous, the bed of the streams being rocky throughout. If the few huts and the cultivated land in the catchment area were bought up, the water drained off must be as absolutely pure as any surface drainage can be."

By Mr. Larminie.

" * * * * *The catchment area chiefly consists of steep, bare laterite hills from which personal observations shewed that even moderate showers are very quickly run off * * * * * * * Analysis of the water taken from the stream under unfavorable circumstances, shortly after a flood, shews it to be remarkably pure * * * Even in the driest season there is, it is stated, a small stream of pure water always flowing * * * *"*

By the Sanitary Commissioner, Madras.

"From an examination of the catchment areas and from the chemical analysis the Hebbal and Dhasarhalli (Rachenhalli) water-supplies are shewn to be subjected to annual pollution, and as there is always danger lurking in a water which is known to be contaminated with animal matter, they are not in my opinion advisable sources of drinking water supplies. The scheme therefore which I would recommend is the Magadi road one, as from a sanitary point of view it undoubtedly would give purer water than either the Hebbal or Dhasarhalli."

By Mr. deWinton.

"Steep hill sides, sparsely cultivated, no manure visible, villages few and far between and only consisting of a few houses. Absorption, contamination both slight, catchment a typical one for a water-supply."

By Colonel LeMessurier, R. E.

"The Maligal river abounds in excellent material for filtering (pulverised, gneiss and quartz)"

By Lieut.-Colonel McNeil Campbell, R. E., Chief Engineer, Mysore.

*"The catchment area * * a very excellent one both as regards purity and run off."*

Result of trial excavations at Nagarbhavi.

95. The excavations behind the reef of trap rock which have been made during the last few weeks at the site near Nagarbhavi proposed for the masonry dam give, I venture to think, most encouraging results, a view which I have reason to believe, is shared in by General Sanford, R. E., D. G. M. W., and Colonel Beresford, Lovett, R. E., Chief Engineer, Madras Command, by both of whom they have recently been inspected.

Suitability of the Ketmarenhalli hill as site for the Service Reservoirs and of Nagarbhavi for masonry dam.

96. They also, I believe, concur in the suitability of the Ketmarenhalli hill, as a site for Service Reservoirs. The site at Nagarbhavi is, it is thought, the only really thoroughly suitable one for a masonry dam on a large scale, although there are many on which smaller ones could with safety be erected. Mr. Larminie was clearly, from what he has written, as to the risk attendant on the construction of a masonry dam, not quite satisfied with the site suggested near the Maligal village and this difficulty is got over by substituting here and higher up earthen dams and having the lowest dam only, at Nagarbhavi, of masonry.

Facility of enlarging the Maligal catchment.

97. The description in Part V of the way in which the natural catchment area can be enlarged shews, it is hoped, that long and extensive contour channels will not be necessary and that the areas thereby tapped will be the cleanest portions of adjacent valleys.

Difficulties attendant on taking up tanks and highly cultivated and populated areas.

98. Not the least of the advantages of the Maligal scheme is the absence of all difficulty or delay in the matter of taking up the ground. The sum of 7 lakhs allowed for acquiring 20 miles of catchment at Rachenhalli is based on information supplied with reference to the similar catchment of Hebbal by the Superintendent of the Mysore Revenue Survey; and is probably sufficiently accurate for present purposes. But there could be no sudden stoppage of cultivation, manuring, and irrigation nor could the land owners be summarily ejected and a series of tanks annexed off the reel for water-supply purposes.

Mr. Standish Lee quoting partly from General Mullin's report in the bound volume of the Bangalore Water-Supply papers wrote as under in 1888:—

*"The resumption of a tank from the rights of the owners of the cultivation under it, is arbitrary, tedious, and disastrously expensive. The settlement of compensation to tanks lower down the valley becomes a very complex calculation, as not only are there the tanks, of which the supply would be directly diminished to a demonstrable extent, but many others which get water from the surplus of the former, and no reliable estimate could be formed of the extent to which these would be affected. The estimated compensation for the Agram Tank, amounting to Rs. 3,11,813 is an instance in point as to the cost and yet, this heavy payment does not secure the abrogation of the immemorial occupancy rights of the ryot to pollute the catchment area by the use of ordure as manure on his fields. Mr. Lyall was of opinion that the taking up for cantonment supply of a tank used hitherto by villagers for irrigation as well as for other purposes is in fact rather a difficult business, and it is not easy to decide how the compensation ought to be assessed. Under these circumstances it would appear that the construction of a tank would be an easier and a more economic proceeding than the acquisition of an existing one * * * * * * * * * * If therefore the cultivated and tank bespangled catchment areas be eliminated from the enquiry as involving complications in the abrogation of vested rights, demanding heavy compensation, and after all yielding but an unwholesome supply * * * * *"*

99. The above is not perhaps a very exaggerated picture of the difficulties of the case. In the Maligal valley there is nothing to prevent the collection of materials being started at once and work commenced on the dam at Nagarbhavi as soon as the design is approved. Within 2 years water should be in the Service Reservoirs on the Ketmarenhalli Hill and pending completion of the distribution scheme, temporary arrangements might be made for bringing it into the towns. In the other case it is quite possible that delay in respect of taking up land and water would seriously interfere with the commencement of work.

Nothing to stop immediate commencement of work in the Maligal valley. Probable delay at Rachenhalli.

If a joint scheme is decided on, with either Rachenhalli or Hessarghatta as the basis, the fact of the Durbar being directly concerned will naturally facilitate a readier disposal of claims; but, as before, careful thought would seem necessary before embarking on what cannot fail to be, to the landowners and ryots an unpopular arrangement, namely that of taking up tanks and removing villages. In the Hessarghatta proposals as they now stand, it is not, it is true contemplated to incur any extensive disturbance of this kind, but here again, the question occurs, how, without such disturbance is the purity of the water going to be ensured.

100. As stated before, the choice of the best scheme for a joint supply appears to lie between Rachenhalli and Maligal and the advantages of the latter are very great. There must assuredly be much hesitation before throwing up either but especially the Maligal in favor of that at Hessarghatta which in the Dewan's own words (see paragraph 14 of his note) will embrace "*a complex system of storage reservoirs subsidiary to a large existing irrigation system and liable more or less to the risk of accident owing to their charact r and situation.*" Under such an arrangement the water-supply system instead of being entirely independent and complete in itself, capable in short of standing or liable to fall on its own merits only, would be hampered by the necessities, and vicissitudes of the huge chain of irrigation tanks above.

A very marked draw back of the Hessarghatta scheme.

101. It stands to reason however, that if the Mysore State is prepared to provide the whole of the capital cost of the scheme and to merely charge the Civil and Military Station so much annually according to the quantity of water to be eventually thrown into it; and if the Government of India and the Civil and Military Station see fit to agree to this arrangement, the choice of a scheme must to a very great extent rest with the Durbar. If they are willing to accept all risk in the matter, it is but fair that they should choose their own theatre of operations. It may be, that they are only prepared to do so on the understanding that Hessarghatta is to form the basis of the scheme. If this be so it is not clear how the difficulty in respect of purity of supply is to be got over otherwise than by a far greater expenditure of money than is now contemplated, and an entire change in the scope of the scheme. On the other hand they may however be prepared to consider the claims of the other schemes and possibly be willing to adopt one of them in lieu of Hessarghatta; or although not prepared to do this, to the full extent of carrying out the works at their own cost they may be willing to share the expenses with the Government of India and the Civil and Military Station, in the same way that they are now doing in the Hebbal temporary scheme. If, it is with the Durbar a case of Hessarghatta or nothing the Government of India and the Civil and Military Station might conceivably to protect their own interests make their acceptance of the proposals conditional on some such engagements as the following:—

If Government of Mysore willing to carry out a scheme at their own expensive choice will to great extent rest with them.

(1.) "*The annual payment for water supplied to be fixed before the scheme is set a foot and will not be liable to increase even if the project exceeds in execution what after careful consideration it is estimated to cost.*

(2.) *The quality of the water to be of a certain standard of purity to be fixed upon by a sanitary expert or a committee of experts*

(3.) The highest points of the station to be fully commanded.

(4.) The control of the distributing arrangements subsequent to the delivery of the water into a separate Civil and Military Station Service Reservoir to be vested in the Civil and Military Station.

(5.) In the event of any scarcity of water the quantities to be thrown into the two reservoirs to be fixed in proportion to the population of the two towns on the same principle as regulated the recent division of water in Sankey's tank."

The rates offered by Mysore would of course be fixed so as to cover all risks and it would then be for the Government of India and the Civil and Military Station to decide whether they should be accepted or whether their interests would be better served by carrying out a separate scheme. These are some of the questions which now suggest themselves and there is, it is thought, very much to be said in favor of the last named alternative namely that, in which one of the schemes would be carried out by the Governments of India and Mysore and the Civil and Military Station as a joint stock affair. Although in respect to initial cost there may not be a very great advantage in a joint scheme the time when great economy would occur would obviously be in the annual maintenance and working charges, one set of pumping plant, one set of pipes, one set of establishment instead of every thing being in duplicate. There are many other reasons, amongst which expeditious carrying out of the work would not be the least why it would be matter for regret that a joint scheme should be abandoned. On the other hand there are certain ways in which convenience might come out of separate enterprises.

Annual upkeep and working expenses.

102. It now remains to consider the all important question of the annual upkeep and working expenses.

In paragraphs 86 to 92 of his report Colonel Campbell has worked these out roughly and arrives at a total annual charge of about 2,55,000 or say 1 rupee per head for a population of 2,50,000

The total is brought about as follows:—

	Rs.
Interest on capital 4 per cent on 31 lakhs	1,24,000
Loss of revenue on land taken up under the tanks	5,000
Establishment	2,112
Depreciation of Machinery 7 per cent on 2 lakhs	14,000
Depreciation of pipes valves, &c. including distribution pipes at 4 per cent on (14,50,000)	58,000
Fuel and small stores	20,000
Repairs at 1 per cent	31,000
Total	2,54,112
Say	2,55,000

The Dewan in paragraph 21 of his note records his reasons for omitting the item depreciation of pipes and there is, it is thought, a great deal to be said in favor of the view which he takes on this subject. On the other hand it has been argued in this report that the cost of the Hessarghatta schemes will turn out much greater than 25 and 31 lakhs and if so the amounts for depreciation of machinery and repair will have to be increased. In the three other projects however, this will not be the case owing to the lengths of the approaches being so very much less. It will, it is thought, therefore be on the safe side, instead of going at length in each project, into the question of interest on capital, deprecia-

tions of pipes and cost of repairs, to assume for each the sums entered for Hessarghatta to the extent below, namely :—

Interest on capital	1,24,000
Loss of revenue	5,000
Depreciation of machinery	14,000
Depreciation of pipes, &c. ..	58,000
Repairs	31,000
Total.. ...	2,32,000

but to go carefully into the remaining items of establishment and fuel and small stores.

Establishment.

103. The establishment shewn in paragraph 89 of the Chief Engineer's note consists of 13 individuals while from page 214 of the bound volume of the Bangalore Water Supply papers it appears that the establishment sanctioned for the comparatively trivial pumping operations, for the troops at the Halsur Water Works numbers 14 including an European Engineer in charge with an Eurasian Assistant. It is, it s thought a question, whether the control of a system of water supply for 2,00,000 people involving the charge of expensive machinery, imported at a cost of 2 to 3 lakhs could be safely entrusted to an overseer on 60 rupees a month. It will be safer to adopt the Dewan's estimate of 7,000 rupees a month for establishment.

Cost of fuel.

104. The cost of fuel is a difficult matter to arrive at and in this connection the following quotation is made from Mr. Larminie's report of February 1889.

"*The entries for establishment should suffice and in making them out the cost of working the elaborate engines which drive the cotton spinning mills at this place has been looked into. These are worked very inexpensively by a far smaller establishment than had now been allowed for, but even this latter is only about half the present Halsur establishment, where also the cost of firewood is greater than at the cotton mills, the reason assigned being that the mills are at liberty to make advances to contractors which a Government department cannot do. At the Halsur works wood fuel has been costing 217lbs. to 270 lbs. per rupee. At the cotton mills rupee 1 per 316 lbs.* * * * * * * * * * * * *of course the comparatively antiquated engines and pumps of the Halsur works could not be as economically managed as the more perfect machines now in the market.*"

The expenditure of wood fuel at the Halsur water works has been assumed at (see page 164 of the bound volume of the Bangalore Water-Supply) 20lbs per nominal horse power per hour.

The N. H. P., in the four projects that have been discussed in these pages would be approximately as under.

In the Hebbal scheme	170
In the Rachenhalli	200
In the Hessarghatta	334
In the Maligal	376

and if for present purposes an expenditure of fuel at 15lbs per N. H. P., costing 300lbs per rupee be assumed the annual expenditure will work out, thus pumping continuing 12 hours daily.

	Rs.
At Hebbal	$\frac{170\times12\times15\times365}{300}=37,230.$
At Rachenhalli ..	$\frac{200\times12\times15\times365}{300}=43,800.$
At Hessarghatta ..	$\frac{334\times12\times15\times365}{300}=73,146.$
At Maligal	$\frac{376\times12\times15\times365}{300}=82,344.$

105. The total annual charges would be approximately.

Total Annual cost and how in time it can be decreased.

			Rs.		Lakhs.
Hebbal	...	...	2,76,230	say	$2\frac{3}{4}$
Rachenhalli	...	...	2,80,800	say	3
Hessarghatta	...	...	3,12,146	say	$3\frac{1}{4}$
Maligal	...	...	3,21,344	say	$3\frac{1}{4}$

From this it would seem that the annual cost of maintenance in a supply for 2,00,000 people at 10 gallons a head per diem might amount at Hessarghatta to $3\frac{1}{4}$ lakhs; instead of 1,86,000 as in paragraph 93 of the Chief Engineer's Note, and to approximately the sums entered opposite each in the other schemes; and the cost per head would be,

	Rs.
At Hebbal	1·38
At Rachenhalli	1·50
At Hessarghatta	1·63
At Maligal	1·63

These rates are possibly higher than they would actually be at Hebbal, Rachenhalli and Maligal and possibly lower at Hessarghatta. Moreover the proposals in the first three projects embrace the purchase of the catchment areas and this permits as suggested in paragraph 100 of last year's report, on the Maligal scheme, of the planting of extensive casuarina plantations which would serve as fuel for the engines, and so largely reduce the cost of pumping. Moreover there are other ways in which the catchments if purchased out-right could be made into a source of income. The growth of grass could be allowed and possibly from a sanitary point of view the grazing of the cattle and sheep would not be objectionable. This would be entirely different to allowing wet and dry cultivation. In the case of Hessarghatta as the complete taking up of the catchment is not contemplated in the interests of the water-supply scheme, it could not be the means of a yearly income to go against the yearly expenses of the scheme. After a scheme had been in working order for a few years there is, it is thought, fair grounds for believing that the annual cost per head might come down from the rates shewn above to something like those given in paragraphs 92 and 93 of Colonel Campbell's report. The cost at Hessarghatta and Maligal will always probably be greater than at Rachenhalli and Hebbal. In the case of Hessarghatta there will be no counter balancing advantage while at Maligal the better water which will be obtained will probably be considered to be worth the slight extra cost involved. It will be in keeping with the main principle advocated, of being contented with a modest commencement, if while pumps and main are provided of such power and size as to be capable of delivering a maximum supply eventually, they shall not be fully worked to begin with. Thus if it is found to be too expensive at first to pump 12 hours a day and deliver water at the rate of 10 gallons a head, the period of pumping and with it the supply might be reduced. When the scheme has got into working order and the catchment has by the produce of fuel and grass begun to give some returns, it will be right to extend the pumping and the daily supply. In common parlance "*you must cut your coat according to your cloth.*" It may be mentioned here that the Virniew Lake of the Liverpool Water Works is plentifully stocked with fish and we were informed that the sale of fishing licenses brought in a very satisfactory income.

106. The last section of this report has been put together somewhat hurriedly in the hope that it may be seen by Colonel McNeil Campbell before he leaves for England, and indulgence is therefore craved for any mistakes that may have crept in. It is hoped that it has put the case, with sufficient clearness, to admit of some decision being come to; so that, it may be the last, of the long series, beginning apparently in 1839, in the time of Sir Arthur Cotton and continuing to the present day. The four projects dealt with, exhaust it is believed all the possibilities, involving pumping, in the near vicinity of Bangalore. Time has not permitted of investigations being made as to the feasibility or

otherwise of bringing in water from Nundidroog by gravity, on which point reference is invited to pages 15 and 16 of the bound volume of the Bangalore Water-Supply.

107. A word in conclusion about Sankey's tank of which many hard things have at times been said. It is I think matter for gratulation that this tank will probably play a part, in whichever of the four schemes is eventually adopted, namely either by its contents being pumped up, into a Service Reservoir or else by its being made over, under some suitable arrangement to the Pettah, for which, owing to its position it is better placed than for the service of the Civil and Military Station. The difficulties, attendant on, the construction of the dam of Sankey's tank can be thorougly grasped, now that it is empty and a close examination of the ground it covers is possible. Easier sites for the dam might have been got either higher up or lower down, but in the former case the capacity would have been too little and in the latter the elevation even more insufficient than (with reference to the Civil and Military Station) it is now. The tank has admittedly not achieved fully the object originally aimed at; but it may well be asked how the inhabitants of Bangalore would have fared by this time, had there not been in November last, those 14 million cubic feet of water in Sankey's. That it has been the means of saving a large expenditure of money and possibly loss of life appears to be undeniable. In this connection then it has been an unqualified success.

BANGALORE,
23rd March 1893.

S. GRANT, MAJOR R. E.,
Executive Engineer, M. W.,
Bangalore Water-Supply Division

This report to be forwarded to Dewan with my own Rough Note.

[signature]
5/5

Mr Dalton

This can go to the Dewan & original with the other papers on Bangalore Water Supply - 12/5/93 [signature]

1893

From

The Executive Engineer,
Bangalore Division.

To The Chief Engineer
of Mysore

Dated Bangalore 5th May 1893

Despatched

Received

Enclosures No. 4

General No. 2020
No. 254

Has the honor to submit the reports called for the Hebbal - Lachenhalli Hesserghatta and Maligal water supply projects:

[signature]

Executive Engineer,
Bangalore Division.

Exp. D.

Hebbal Scheme

The report on this scheme is so confusing, that it is impossible to decide with certainty the scope of the proposed extension of the project:—

2.—In para 25, it is proposed to acquire as additional gathering ground the catchment area of ×Honnenhalli—×Rajakunte—Thimsan and Tarkunee tanks, measuring 5·2 square miles (See table A); and in latter part of para 26 it is stated that this catchment area would be increased by the gathering ground (3⅛ sq. miles) above the masonry duct, yet, from calculations based on the cost of the work as given in the same para, a masonry duct that would carry a run off of 1" per hour from 10 acres, has been provided for.

The names of these tanks are Shinga=ikenhully and Aliganhulli [illegible] to prevent confusion, the [illegible] mes given them by Major Grant [illegible] be adhered to.

3.—To discharge a run off of 1" per hour from the combined catchment area of tanks mentioned in para 25 of Major Grant's report and that of gathering ground above the masonry duct would [illegible] channel with [illegible]

width of 210 ft flowing
ft in depth, and as it is evident from the statement
cost that no such channel has been provided for, as is intended, the additional catchment area comprized in the gathering ground above the masonry dam cannot be considered as catchment area with reference to this project, in fact to avoid serious damage to the channel, costly, life & damages would have to be constructed to pass the run off from such gathering ground across the masonry dam. ——

4. It being quite evident that it is not proposed to discharge the run off from the additional catchment as received, a storage reservoir is absolutely necessary, and cost of the same, and its bearing with relation to available quantity of water over the additional catchment area will now be considered. —

The storage reservoir is proposed to be constructed by throwing a masonry dam across the valley of the Kadavadi river at a point about 2.26 miles from the catchment of 5.9 sq miles, it is proposed to construct a masonry dam of 210 ft length and 6 ft in depth, and as it is evident from the statement cost that no such channel has been provided for, as is intended, the additional catchment area comprized in the gathering ground above the masonry dam cannot be considered as catchment area with reference to this project, in fact to avoid serious damage to the channel, costly, life & damages would have to be constructed to pass the run off from such,

Statement of tanks proposed to be acquired for additional Catchment of Hebbal tank R. No. 46 S. No. 62 Kadgody Series.

Serial No.	Name of tank	Catchment area	Waterspread at R.L. 50.00	Waterspread at R.L. 53.00	Capacity at 50.00	Capacity at 53.00	Stock value of tank	Number of Cyds of water stored per Rs
36	Shingenaikenhully	1450	254	356	~~199~~	282.5 ~~267~~	10,353	264
34	Adiganhully	460	22	34	7	21	2,046	31
33	Timmasundra	951	78	101	52	97	2,368	210
32	Tharulumse	466	33	25	14	28	2,644	51
	Total	3,327 or 5.2 Sqr Miles	387	..	272	..	17,411	

Maximum run off at 17 M.C. ft per Sqr Mile = 88.4 M.C. ft or 338.5 units

To store maximum run off capacity of Shingenaikenhully tank must be increased by 56 units which would necessitate the raising of Weir 2½ ft and waterspread of tank would be increased by 84 acres the compensation for which would probably amount to Rs. 5000 as Casuraina plantations will be submerged – Wet land below the four tanks measures 259 acres, the compensation for which would amount to not less than Rs 25,900 –

Loss of revenue would be Rs: 1511, which capitalized at 4½ % amount to Rs: 33500

As the Bangalore Hindupur Railway line passing through a portion of the bed of the tank is now only 8 ft above

weir level, the raising of the weir 2½ ft would necessitate ~~the raising of the weir 2½ ft would necessitate~~ the the railway line the minimum cost ~~therefore~~ of which probably be Rs 10,000.

The total cost therefore of the utilization of this catchment area of 5.2 Sqr. Miles would be as follows.

1. Present value of land tracts _____ Rs 17,411
2. Cost of increasing capacity of Shinganakanhully tank Rs 5,082
3. Compensation for land submerged by raising weir _____ 5,000
4. Compensation for wet land thrown out of cultivation _____ 25,900
5. Loss of revenue capitalized at 4½ per cent ~~[illegible]~~ 33,500
6. Raising portion of Bangalore Hindupur line _____ 10,000

Total Rupees 96,893

and capacity of three tanks above is 73 units or 19 M. cubic feet (See Statement A).

With a maximum run off of 17 M. C. ft. per Sq. mile, the total quantity received would be 88·4 M. C. ft., and storage capacity of Honnenhalli tank would have to be increased by 14·6 M. C. ft. the cost of which would amount to upwards of Rs. 96,893 (vide Statement A).

5. The advantages with regard to supply accruing from the additional catchment will now be discussed:

The rate (Rs. 2 per rug ft.) allowed for masonry channel in para 2 will certainly not admit of the construction of a channel with waterway of more than 4½ sq. ft. and with fall (2 ft. per mile) mentioned by Major Grant. Such a channel would discharge 300,000 cft. per day of 24 hours at which rate it would take 177 days to run out the full quantity of water proposed to be stored in the Honnaikenhally tank during this time percolation and evaporation would

at fertight reservoir than Hon-
nenhully, the loss during conveyance
water inclusive of loss of 15 per
cent in transit would be 34·36
M. C. ft, and quantity delivered
in Hebbal tank would be only
54·04 M. C. ft, which ~~it~~ is virtually
reducing the catchment area
of 5·2 Sqr miles to 3·18 Sqr miles —

6. — Allowing however that by
means of contour channels of
large section the ×whole of the
run off from his catchment
is available, the total catchment
area of Hebbal tank would
be only 21·98 say 22 Sqr miles,
the maximum run off from
which at 7 M. C. ft per Sqr mile
would be 374 M. C. ft, — and
minimum at 7 M. C. ft per Sqr mile
154 M. C. feet. —

7. — Calculating the available
supply for three years as per
these figures, in the same way
as was done in the Hebbal
project (viz = tank full to start
with and minimum rainfall
of 12 inches for the preceding
year) the result would be
that at the commencement of
the third year, there would be
a deficit of 5·5 M. C. ft, instead

× it should here be stated that
this is most unlikely, as with
catchment channel 12 miles
in length with fall of 2 to 3 ft
per mile, much of the [illegible]
must unavoidably be lost :—

project:—

8.— As even under the most favorable circumstances the run off from the increased Hebbal catchment is insufficient; it is unnecessary to enter into details with regard to cost of project, but I would mention that the raising of the weirs of Hebbal and Homenhalli tanks would necessitate the raising of the Bangalore-Hindupur Railway, which would prove very costly, and for which, as well as for cost of Homenhalli and other tanks, no provision has been made in estimate. I would further beg to add the following remarks with regard to Paras 16, 20-26 & 29 of Major Grant's report.

1st (Para 16 — run off) — the percentage of run off does not invariably increase with the rainfall, for the following reasons.— during a year of good rainfall the fall is generally spread over such a long period that sometimes only $\frac{2}{3}$ or $\frac{1}{2}$ of it is effective. — —

In 1880 with rainfall of [illegible] inches only 28·28 inches (not $\frac{3}{4}$ th) was effective, while in 1881 with rain of 21·63 inches, 17·91 inches (over $\frac{4}{5}$ ths or nearly $\frac{5}{6}$ ths) was effective.

In 1888 (year mentioned by Colonel Campbell in his report on [illegible]

34·30 inches, of which [illegible]
ly 24·5 inches was effective, and
of this only 15·24 inches gave an
appreciable run-off, the total
run off being 1/10th the rain fall —

In 1892 with rain fall of 27·03
inches only 16·46 inches was effective
and run-off was 11·59 M. C. ft. per
sqr. mile equal to 18·5 per cent. —

2nd para 20. — "Theorizing" cannot e[illegible]
certainly with any justice be
applied to the Heeserghatta project
as Statement E submitted with
report conclusively proved that
run-off of 11. M. C. ft. per sqr.
mile was correct for an average
year; I would also submit that
the data obtained after years
of careful investigation of
run-off from Sankey's reservoir
can hardly be classed in such
a category. —

3rd para 26 — The actual catchment
area of Honnenhalli and tank
above is 5·2 sqr. miles, and not
3 sqr. miles as stated by Major
Grant, while that of [illegible]
ground above [illegible], a[illegible]
3·12 sqr. miles, so that compensation
would have to be paid to
8·32 sqr. miles which, as most of
the land is [illegible] would
amount to at least 4 lakhs
instead of Rs. 75000 as assumed
by Major Grant. —

4 i para 29-(3) — para 5 of this report, it has been shewn that the effect of utilizing the catchment of the Hoimenhalli tank, as proposed by Major Grant is that 25 per cent of it is lost, and as further extension North of Yarkunde would result in a still greater loss I think any such extension would certainly not be advisable: —

R. Caldwell

Executive Engineer,
Bangalore Division

Bangalore
18th May 1893

Exd Dr.

Kachenhully Project

9. X. — In para 5 it is stated that the catchment area of his tank will consist of 15 sq. one miles of free catchment, and 21 square m. of catchment of Yellahanka and tanks above, and further that "the catchment" is so very similar to that of Hebbal that it will be quite safe to assume the same "run off" as in para 21 of this report.

10 With reference to the last e[illegible] a sumption I would certainly demur, as in the first place there is very little waste land, in the second place the catchment generally is gently undulating ground, and in the last place there is hardly a bit of it similar to that described in para 19(a) of Major Grant's report, and I would here state that it would certainly be inviting a repetition of [illegible] "Sankey's folly," if any thing, [illegible] more than a [illegible] of [illegible] M.G. ft. per sq. mile was counted on in the best of years. — —

11 ~~8~~. — With regard to the latter part of para 20, to the effect that "it is conceivable that the Kachenhully catch[illegible]

for the water supply of the Civil and Military Station and the "Pettah." I would point out that the bed of Rachenhulli tank is very much flatter than the bed of Hebbal tank, and evaporation would therefore be much greater, consequently if ×22 sq.r miles catchment area is insufficient under the most favorable circumstances for Hebbal, it is obvious that a catchment of 15 sq.r miles will not suffice in the case of Rachenhully.

× vide para 6 & 7

12 Q. — In para 33 Major Grant states that "if, in addition to the 15 sq.r miles, the Yellahanka tank and the catchment in its immediate vicinity, say some 4 or 5 sq.r miles be taken up, that would suffice for the requirements of both towns for many years to come," but as it has already been shown in the preceeding para that a catchment of 22 sq.r miles will not suffice, it is unnecessary to enter into details to prove the fallacy of this supposition. —

13 Q. — It may be said that the surplus from tanks above Yellahanka would add greatly to the supply, and with reference to this I would offer the following remarks. —

There are 19 tanks situated

This figure is wrong. The Capacities of the Yellahanka cries down to and inclusive Yellahanka tank only aggregate 271 M.cft.

[signature]
7/5/93

within the so called outlying catch of 21 Sqr. miles, the combined capacity of which is 296 M. C. ft., and allowing run-off of 7-11- and 17 M.C. ft. Sqr. mile during bad, average and good years the available quantity would be 357, 231, and 147 M. C. ft. respectively, which means that during a good year the catchment area equivalent to the surplus run off would be 3·59 Sqr. miles, — this added to the catchment area of 19 Sqr. miles adverted to by Major Grant, gives a catchment area of 22½ square miles in good years, and 19 Sqr. miles only in average and bad years. —

11. — The catchment hitherto rejected to being quite inadequate, it will now be considered what the result would be of the acquisition of the whole catchment area, 36 Sqr. miles, of the Rachenhulli Sub Series, firstly with reference to supply, and secondly with reference to cost. —

1st — The run off from the 36 Sqr. miles of catchment would be (accepting the figures given in the preceeding para which are those adopted for Hesser=ghatta project) 612, 396 and 252 M. C. feet respectively for good, average, and bad years. —

2nd — If impound the maximum run off of 612 M. C. ft. it would be necessary to raise the waste weir of Rachenhulli tank about 20 ft., at which level the water spread of the tank would be approx...

approximately 1132 acres. ——

3rd Now supposing the maximum run-off to have been impounded prior to commencement of the water supply of both stations and the two following years to be years of bad rain fall, the result is as shown below, worked out on the same data as allowed for Hesser-ghatta project. ——

Reservoir full at commencement of water supply to both stations		612 M.C.ft.
Annual consumption	182 M.C.ft.	
Percolation at 15 per cent of average contents of reservoir	75 "	
Evaporation of 6 ft. per annum of mean area of water spread	246 "	
Total	503 "	503 "
		109 "
Add quantity received during year		252 "
Balance at end of first year		361 "

Consumption during 2nd year	182 M.C.ft.	
Percolation	60 "	
Evaporation	107 "	Total 439 "
Balance minus		78
Add quantity received during year		252
Balance at end of 2nd year		× 174 "

12th Q. With the whole of the catchment of 36 sq. miles acquired the Rachenhully project would answer for the water supply of both stations provided the minimum rain fall (7 M.C.ft. per sq. mile) assumed is correct but should the yield turn out to be only 6·15 M.C.ft. per

× With reduced supply of 10 g per head per day for 20,000 people, there would be a sur of 225 M.C.ft., allowing a minimum run-off of 7 M.C.ft. per sq. mile, but with run-off of 3·15 M.C.ft., per sq. mile the surplus at end of second would be reduced to 100.

per square mile, as allowed by the Colonel Campbell for the Hesseraghatta project, the result would be that instead of a surplus of 174¾ c.ft. there would not be any water left in the tank at end of second year.

— With regard to the minimum run-off of 3·15 M. C. ft. per square mile, I would state that it is quite possible the run-off from the Rachenhalli catchment of 36 sq. miles may not amount to more than this, as the data collected from the small catchment of 2¼ sq. miles of Sankey's tank is no criterion for calculation of the yield from a large catchment like that of Rachenhalli, it being a well known fact that the rain fall on which the filling of tanks depends is generally confined to very limited areas. The difference in rainfall at Sankey's tank and Executive Engineer's Office is frequently from 1 to 2 inches, while on the small catchment of 2¼ sq. miles of Sankey's tank the [illegible] is different [illegible] ground [illegible] variations of 1·83 inches.

+ 5·5 Allowing however that the yield from the catchment [illegible] will suffice it, will be seen from the following [illegible] that the cost would be prohibitive.

(a) The catchment below the Vellahankatan, called the [illegible] catchment, is not [illegible] and it would be absolutely necessary to acquire the whole of it — [illegible]

miles consists of wet land the rate for which would be at least Rs. 145 per acre while for dry land it would probably amount to Rs. 75 per acre on an average. —

(b) The dead stock value of the 31 tanks comprizing the sub series, is as per books of this office Rs. 1,10,000. —

(c) The statement of assessment on the "free catchment area has not yet been received from the Revenue Department, but it is approximately Rs. 17,378 - which capitalized at 4½ per cent amounts to Rs. 3,86,200." —

(d) Of the outlying catchment of 21 sqr. miles nearly 1 sqr. mile consists of wet and garden land which must of course be brought up, and if the tanks are breached it will probably be necessary to resume at least *⅓ rd of the area of dry land, as no water will be available for man or beast. —

1(e) Calculating the compensation which will have to be paid in accordance with above statement, it amounts to Rs. 17,57,170, as per details given below, whereas Major Grant has allowed only Rs. x 7 lakhs on this account and his estimate of 20¼ lakhs must be increased by 15¼ lakhs. —

Free

* It should be noted here that secure any prospect of run like that from Sankey's cat the whole area of 21 sqr. mile must be purchased. —

x 7 lakhs stated to be proba amount of compensation para 33 of report, but on 2¼ lakhs allowed in abs estimate given on page report. —

826 acres of wet land at 145/- per acre ——— = 1,19,770
8768 — " — of dry — " — at 75/- — " ——— = 6,47,600
Assessment of Rs. 17,378 capitalized at 4½ per cent = 3,86,200

Outlying Catchment

570 acres of wet and garden land at Rs. 100/- ——— = 57,000
4480 — " — of dry land at Rs. 50/- ——— = 2,24,000
Assessment of Rs. 9,570 capitalized at 4½ per cent = 2,12,600
Dead stock value of 31 tanks ——— = 1,10,000

* Total Rupees = 17,57,170

If to this is added the compensation etc. for the remaining 13 sqr. miles of land, the ~~cr~~ amount must be increased by 6·93 lakhs. ——

15 ~~13~~. It is very probable it may be said that judging from the analysis of water and reasoning from analogy, it is not necessary to throw dry land out of cultivation in the Rachenhully catchment, if such a proceeding is not essential in the Hesserghatta catchment — with reference to this I would state that the analysis of the water is most misleading, an inspection of both catchments while the land is under cultivation would convince anyone that if the water in Hesserghatta tank is "suspicious" that in Rachenhully is noxious, and I am sure quite a different result would be obtained from the analysis of water taken from the tank in June or July — the Rachenh

catchment below Yellahanka being as already stated, the most heavily manured land in the Province.

In the case of Hesserghatta it is quite different - it will be seen from statement A, submitted with that project, that notwithstanding ample water is available only $\frac{1}{4}$th to $\frac{1}{3}$rd of the land is under cultivation, which is due to manure not being available, and to insufficiency of population as statement given in page 30 of report on the [illegible] will show.

16. With regard to resumption of dry land in "outlying catchment" I have already given reasons, for the same in para 14(5) 12 of this report, and would simply invite attention to the topographical survey map showing both catchment areas, from which it will be at once seen what a vastly different matter it is to take us eight tanks situated within an area of 10 sqr miles with numerous adjacent tanks to taking us 31 tanks within an area of 30 sqr miles, with only half a dozen tanks situated within a mile of the watershed or three miles - on the centre of the valley!

147 On page 41 Major Grant

gives the cost of bund and wa
weirs, according to the Hesserghatta
data and specifications as
Rs. 1,50,000 — I have had longitudinal
and cross sections of the bund
of Bachenhully tank taken
and find the actual estimated
cost of a storage reservoir to
impound 612 M.C.ft. (the quantity of water
proposed to be stored at
Hesserghatta is 880 M.C.ft.) amounts to
Rupees 2,05,959 ~~instead of 1,50,000~~
~~as given by Engineer General in page~~
~~4 of his report~~

Bangalore
2nd May 1893

Executive Engineer,
Bangalore Division.

Exd. [illegible]

Hesserghatta Project:

18~~15~~. Colonel Campbell has en so clearly shewn the fallacy of Major Grant's criticism of this project, that any further elucidation of the matter in this respect is unnecessary, I would however beg to offer the following remarks with regard to points referred to in the undermentioned paras

~~16~~. — Para 40 (a). — It is misleading to quote the statement of rain fall in Hesserghatta report in the sense given by Major Grant, as it was distinctly mentioned in the statement that the return of three stations were incomplete and untrustworthy. —

(There ~~is~~ was no assumption in the report on Hesserghatta project that a catchment of 30 sq. miles would suffice "for the effective supply of 200,000 people" — in para 45 of the report it was stated that the catchment of 30 sq. miles "would not half fill the impounding tanks in ordinary years and it ~~is~~ further clearly shewn that the project mainly depends on the surplus available from tanks above, with regard to sufficiency of which there ~~can~~ be no question (vide statement I.

(b) The cost of the catchment &c.

discussed in para 14(5) and shown to be prohibitive with regard to the Rachenhally project, and I would submit that it is therefore unnecessary to consider the further extension of gathering ground that can be effected by acquisition of Hebbal and Nagadevanam catchments and failure of tunnelling to increase the supply to an extent proportionate to the drainage area and expenditure has been shown in para 51.

(c) The benefit of Hesseraghatta over Rachenhally is that no further extension of catchment will ever be necessary, whereas in the case of Rachenhalli it would be an immediately so and cost of acquisition of 50 Sq. miles can be gathered from that given in para 12(5) for 23 Sq. miles.

(d) With regard to construction of mills and manufactories on the upper portion of Hesseraghatta catchment area I would simply request perusal of para 21 of Colonel Cairnduff's note [illegible]

(e) In practically there is no difference in the circumstances of a water supply based on the Rachenhalli Series and of one starting from Hesseraghatta. There is

consider practically a very great difference, which the annexed statements will I think prove ~~be the case~~ —

Messerghatta	Rachenhally
Condition of catchment	**Condition of catchment**
Sparsely populated and only ¼th to ⅓rd of wet land cultivated, and dry land so slightly manured as to render its acquisition unnecessary. — Land of ordinary value —	Densely populated for Mysore — the whole of the wet land cultivation and dry land more heavily manured than in any other part of the Province, in fact, to such an extent below Yellahanka as to make it absolutely necessary to throw it out of cultivation. — Land the most valuable in the Province —
Extent of catchment	**Extent of catchment**
Practically unlimited, and extension beyond the 30 sqr miles now proposed will probably never be necessary, as gauge readings taken in March and April show a daily influx of 600,000 cft. —	Limited to 36 sqr miles natural catchment and extension, which would certainly soon or later be necessary, only feasible at an enormous cost, —
Tanks comprised in project situated at short distances apart, and proximity of other tanks such as to render it unnecessary to throw land out of cultivation owing to want of water.	Tanks comprised in project scattered, and there not being any other tanks in the proximity ~~makes~~ it necessary to acquire land solely because water would not be available with a reasonable distance
Reservoir	**Reservoir**
Bund strong and water-tight with top width of 50 ft —	Bund weak and leaky with top width of 8 ft. —

(2) ~~1/~~ Para 41 — Other things are I would submit most unequal —

and in paragraph 42 it has been shown that the cost of the Rochenthally project even on what Major Grant styles "the Hesserghatta data and specifications" would cost 43⅓ lakhs instead of 22½ lakhs as stated in report! ——

With regard to "precautions to insure the watertight earthen dam" I would here mention that all necessary precautions have been taken, and difference of cost is due to there being in the case of Hesserghatta a good massive dam to work on, whereas in the case of Rochenthalli it is quite the reverse, as is evident from Mr. De Winton having considered the existing bund so leaky and worthless, as to make its inclusion in the new dam inadmissable. ——

(3) Para 41 — II d — The cost of distribution has not, so far as I am aware, been worked out for any project, and with reference to Major Grant's direction that "the water for distribution heretofore, has been entered at from 3½ to 4 inches per head, the allowance being 6½ gallons per day," in the Hesserghatta project the water is kept the same while the amount to be carried is doubled", I would state that in Mysore, where the supply

is much greater than proposed in the Hesseraghatta project and need not to be compared with that given by construction of service under main Part of same till the rate for distribution is Rs 5 per head, and from a calculation made some years ago for water supply of a portion of Bangalore City, I am of opinion that, considering the Native quarters in both stations are densely not located, & Native habits & the benefit of the protection to be derived the average rate of Rs 3½ per head served in the Hesseraghatta project will prove sufficient. ———

(4) Re Paragraph III. The Revd Archdeacon's objects is undoubtedly to secure to the Bangalore Cantonments, as is situated so close to the Lalbagh, what is now well known as the Botanical Garden, & to which it is desirable to add a Botanical Garden, & to which it is desirable to add a Botanical Garden, & to which it is desirable to add a

to burn up all wet cultivation draining directly into Hesserghatta tank, which has been ~~done~~ provided for.

(5) ~~20.~~ Para 41-III. As no details are given ~~with regard to cost of Hesserghatta project~~ if carried out "on lines hitherto accepted at Rachenhalli" it is impossible to ascertain how the result that Hesserghatta project would cost "over 150 lakhs" has been arrived at.

In the preliminary report all possible care was taken to leave a workable margin, on all sub heads of work, and the only alteration in estimate I consider necessary is that cost of pump and engines should be increased by Rs. 1,12,000, but against this a saving of Rs. 1,54,836 would be effected by use of steel pipes.

(6) Parallel.

~~21.~~ With regard to this para ~~42~~, I annex the analysis of water as given in the Madras Government papers on water supply of Bangalore pages 122 and 123, to which I append an extract from page 216 of the same papers with reference to "Water pronounced bad" not being necessarily injurious

Analysis

is water. P es 122 and 123 ~ "
water s s above

Mali		ample of taken	am + Hesser	amp / from Miller's reservoir
al Solids 0·420	grains per	0·25	0·25	0·25
atile Solids 0·100	DO	0·10	0·09	0·08
lorine 0·0[illegible]	DO	0·043	0·028	0·039
al hardness 7°	Clark's scale	4°·2	5°·6	3°·15
nment hardness 0°·35[illegible]	DO	1°·75	1°·05	1°·75
e ammonia 0·4[illegible]	Nelgrains per litre	0·12	0·12	0·20
menoid ammonia 0·08	DO	0·16	0·32	0·40
tric acid 0·[illegible]	DO (as ammonia)	3·00	0·30	2·10
arent quality of water as inferred the results obtained on examination		usable	Suspicious	usable

Extract from Page 216 of Madras Government papers on water supply of Bangalore

"Water pronounced bad not necessarily injurious"

"No chemist can authoritatively pronounce that a water is unwholesome; all he can do is, having fixed on a standard of purity, to say that the waters submitted to him for analysis depart in certain respects from that ideal standard"

"Mr. Ekin (analytical chemist) quite agreed with the author and Doctor Thundichum as to the little value to be attached to the determination of organic matter in water, because he had over and over again examined water that had undoubtedly given rise to typhoid fever and found that it contained a very small amount of organic matter and he had gone into Districts where there could be no sort of contamination and examined the springs, rivers and [illegible]

a large amount of org[illegible] matter that by no test could be distinguished from the organic matter in sewage". —

"The existence of an infectious property in water cannot be proved by chemical analysis". —

"The various processes of water analysis had one and all been shewn on chemical grounds to be worthless, and he had ev endeavoured to prove that they were worthless (as far as the power of indicating wholesomeness was concerned) by reasoning which required no technical knowledge to follow it". —

"Professor Tyndall agreed with Doctor Thundichum that chemical analysis would afford but little information as to the deadliest things that might be in the water". —

[signature]

Bangalore
3rd May 1893

Executive Engineer,
Bangalore Division.

[illegible]

The Matiyal Valley project—

19 ~~21~~ From para 45 to para 48 of Major Grant's report is simply theorizing with reference to rain-fall and run-off — that "there have been frequent pools of water on the surface of the sand", or that "water has been obtainable by scratching holes in the sand", gives no idea of the quantity of water available from springs, any more than the fact of "clear traces of a run-off being visible after a shower of 15 cents at Usurrock" proves anything definite with regard to quantity of run-off. — Neither does the fact of there having been a flood in the Matiyal nullah 6½ ft in depth on the 26th August, when there was a rainfall of 2.68 inches at Hebbal, in any way prove that the run-off was 3/5th of a fall of 3" distributed over 6 hours — the essential information on which the accuracy or otherwise of such a calculation

calculation could be
being wanting.

20 22. I know the Matigal
ment area well, and con
it quite possible that the
may be double that in the
Sankey's catchment, but
does not follow that the to
run-off from 10 sqr mi
would be ten times that
2 sqr miles of Sankey's ca
=ment — it being a well k
fact that increase of catchm
is not proportionate to inc
in quantity of water recei
the reason of which is fully
explained in para 11 of
report.

21 In 1887 tank was co
=structed for the water sup
of the Bangalore distiller
below a catchment very
similar to that of Mag
valley

valley, and not far from it, and judging from the run-off from that catchment, I feel certain that a water supply project based on run-off per sq. mile of 10, 28 & 46 mcft in years of bad, average, and good rainfall respectively would prove a failure.

22 With reference to para 49, there is no doubt that by this time Major Grant is aware of the incorrectness of Captain Ward's table of loss due to evaporation in Stebbal tank, the sluices of this tank were closed on the 12th December 1892 and notwithstanding a small supply was received from the Hodihulli tank, situated immediately above, there has been a steady average fall of 1/5" inch per day, although there has almost an entire absence

of the high winds which
in March and April

As stated in para 22 I am
acquainted with the Mag[illegible]
valley, and am sure tha
will be found very much m
difficult to construct a
=tight reservoir at all fou
sites mentioned in the Mag
valley than at either Hebbal
Rachenhalli, and granti
this, and considering the p
=sure due to greatly increa
depth of water, I am certain the loss throu
percolation will be greater at
Maligal than at either of
the latter places, and quantit
should be increased, instead of
decreased 50 per cent, as done
by Major Grant (vide para
50 of report.).

2 ~~4~~ The Maligal Magady valley project
as now proposed by Major
Grant consists of 4 reservoirs
"each with an average water=
=spread at full tank level of
about 124 acres, and a capa
=city of

of about 100 to 108 M cft."

25 — To fill these reservoirs Major Grant has assumed a run-off 2/3 times greater than the maximum hitherto allowed, — no valid reasons are given for this, and I would submit that in the absence of reliable data for such assumption, it should not be accepted, especially as well established Experience ~~Practice~~ is against it, and a second Sankey's folly would indeed be a disaster

26 With even double the maximum run off hitherto allowed only three out of the four reservoirs would fill, and allowing that the maximum, average, and minimum run-off from the Meaggady catchment is double that from Sankey's catchment (against which I must most earnestly protest) as no

and accepting
figures for evaporation & percolation,
result at end of five years
would be a deficit of £58.

tank Reg: no: 34

56 – area under cultivation 112 acres and approximate revenue Rs 600.

atchment area — 1924 acres

ater spread. — 106 acres

apacity — 59 units: 15 M cft

ead stock value Rs 6024.

aste weir — 2962.74

Sluice — 2956.29

ow of the Ry. culvert — 2961.13

angalore – Hindupur

railway line — 2966.73

— 2968.33

M railway — 2970.37

saddle. — 2976.43

46. The increased catchment proposed in para 55, consists of 3 sqr miles of Tanniranhalli drainage – 3 sqr: miles of Hell drainage, proposed apparently to be stored in Tanniranhalli tank, and 4 sqr: miles of Hallab and Malathalli drainage to the south west of Nagarbhani —

From levels given in the margin it will be seen that the capacity of the Tanniranhalli tank cannot be increased without raising the Bangalore – Hindupur Bangalore Kaiti [illegible] and Southern Mahratta lines of railway, and as cost of this would be prohibitory, the advantages to be gained from the extra catchment of this tank would be the supply of 15 M. cft minus 2 M. cft lost in transit:-

28 Major Grant estimates the cost of adding the Tanniranhalli catchment to the [illegible] project at Rs 43,000, but he has omitted the val[illegible]

compensation for land thrown out of cultivation below the tank, and loss of revenue, which at a low estimate would amount to Rs 36,000: - -

With regard to the 3 sqr: miles of Hebbal catchment, if this is to be of [illegible], a storage reservoir must be constructed, the cost of which, if maximum run off of 17 in cft per sqr: mile, is to be saved, would amount to Rs 50,000, [illegible] Hesserghatta rates - in addition to this it would be necessary to have a delivery [illegible] [illegible] with masonry duct about 3 miles in length, costing Rs [illegible], as per Major Grants figures, to which would have to be added compensation approximately Rs 12,000 for land taken up for tank and [illegible], [illegible] makes the [illegible] of this [illegible] Rs 1,10,000 instead of Rs 15,000, as assumed in para 57 of Major Grants report.

expenditure a supply
C.ft might be
anticipated in a year of
ood and 15 M. C.ft in a year
bad rain fall:-
rior to discussing the question
catchment to the south
est of Nagarbhani, I would
mention that much of the
sqr: miles of catchment
ferred to above is heavily
manured, and that immediately
low the saddle the ground is
friable ~~that it is~~ cut up
to a mass of ravines ~~and~~ that
masonry duct would
required from Tannirhalli
tank up to the first dam,
as if the supply ~~was~~ were allow-
to fall into the ravines, as
apparently suggested by
Major Grant, very little
of it would find its way
into the reservoir: --
The supply from the catchment

of Hallal and Mulathalli;
situated to the south west
of Pherwani is proposed to be
discharged into the [illegible]
reservoir, consequently in
good and [illegible] [illegible]
it would only be of use after
the supply [illegible] the [illegible]
upper dams & the extra
catchment to the north
of the valley had been
exhausted, and such being
the case, it would be of little,
or more probably of no benefit,
as the water stored would
be [illegible] evaporation and
percolation [illegible] it
could be used. — In bad years
the quantity (about 8 M cft)
stored by the tanks would
be available [illegible] 1 M cft
lost in transit — No allowance
has been made [illegible]

Major Grant for cost of tanks, compensation for land, and loss of revenue on this catchment area, and as details on which the actual amount which would have to be paid on account of the same are not forthcoming, it will be assumed that Rs 20,000 is a fair sum to allow:—

~~24.~~ Further extension of catchments to Rachanhalli on the North, and by means of 7 outer channels, to the South & West of reservoir are alluded to in pa[illegible] 58 & 60, and with regard to such extensions, I would state that for reasons given in paras 5[illegible] of my report, such [illegible] catchments would be of [illegible] little use and the cost would be utterly disproportionate to the advantages gained — as however these extensions are [illegible]

mentioned as possible in the far future, the question of sufficiency or otherwise, of supply is limited to the run off from the catchment area of the Magadi valley above Kaambhani and that of the 9 sqr: miles referred to in the preceding paras. —

32. In para 26 it was shown that even allowing the run off from Magadi valley catchment to be double that of Sankey's, and accepting Major Grant's figures for evaporation & percolation, the result at the end of five years would be a deficit of 45 M. cft, and as the twelve sqr: miles of extra catchment will only yield 170 M. C. ft in 5 years, the result would be a surplus of 125 M. C. ft at the end of that period —

Lannirahalli	5×13 : 65
Hebbal. —	2×15 : 30
"	2×20 : 40
"	1×35 : 35
Total —	170

32:- It must not be forgotten that the result arrived at in the preceeding para has been deduced from most fallacious premises, and had the calculations been based on the hitherto accepted data with regard to rain fall, run off, percolation, and evaporation, the result would have been entirely different.-

33:- With regard to the rates for earth works and puddle for the main and subsidiary dams, given in paras 65 and 66, I would state that it will be impossible to execute such works at either site for these rates, the circumstances being quite different from those pertaining at Hesarghat. At the main dam, and first subsidiary dam it is possible that earth works might be executed

Rs 7/- per 1000 for earthworks
Rs 12/- per 1000 for puddle

executed at an

30 per cent, but at the

dams 50 per cent Extra

covers the cost, and at

of the sites could clay

be executed at less then

per cent over Hessergh

I have had an Estim

prepared of cost of dam

impound 108 m c. ft at

second site mentioned by

Major Grant, and find

the cost of the same on

"Hessergh atta line, specific

and rates" amounts to Rs 1,00,4

and if to this is added 50

cent for earthworks, and 7

per cent for puddle, the

would be Rs 1,34,878

the act of third ~~second~~ dam ~~the cost~~

would be the same, as

for the upper one

would be Rs 1,24,063,

which makes the tot

cost of three dams Rs 3,93.

instead of 2,70,000 as given in para 66 of Major Grant's report:-

34 ~~31~~ — Paras 67 to 77 of Major Grant's report consist of comparisons between details of execution and cost of works in the Hesserghatta and Maligal projects, and is mostly a repetition of the criticism on the former project, which has been replied to in Colonel Campbell's memo, and the only point necessary to notice here, is the statement that the conservancy requirements are the same in the Maligal valley as in the Hesserghatta catchment and the provision for

compensation

compens-ation
be reduced from
Rs 50,000 — with
to this I would
that the Messenghatta water
under existing circumstances
has been proved to be a
good ~~potable~~one and that
proposed conserv-ancy
arrangements and prohibito
of further cultiv-ation will
lead to improvement, but in
the case of Varigal v-alley,
it is quite different, as unless
the land is purchased, ~
cultiv-ation (which with
increased population will
undoubtedly be extended)
cannot be prohibited, and
should the valley become
cultiv-ated, the sole redeeming
point in the project will
be lost, as owing to the
proximity of the catchment

to Bangalore, manure of the ~~[illegible]~~ kind will be profusely used, and the water will in a short time become as bada that at Rachenhalli. —

35. — Allowing that it is necessary the entire catchment should be brought up, the compensation will still stand at Rs 2,50,000, and adding to this Rs 1,00,000 for pumps and engines, which should not have been deducted when comparing cost of the project under "Hesserghatta data and specification", also the sums noted in margin omitted by major grant, the cost of the maligal project on "Hesserghatta data and specificat-

Cost of matlaire tank, compensation and loss of revenue &c - Rs 36,000 (See para
Cost of storage reservoir and other charges in connection with the Hebbal catchment ——— Rs 1,10,000 — " ———
Cost of Malathalli tank and charges in connection with same — 15,000 — " ———
Extra cost of 3 dams, as per Hesserghatta line and specification ——— 1,23,000 (See para 30)

instead of 26 l
in report:—

3b. — With regard
Part VI "General
of major grants"
I would, notwithst
it will be a recapitulation
of what has already been
written, offer the following
remarks.—

(1) Para 84-(2) ~~That~~ with
respect to both quality
and quantity it is necessary
to go to Hesserghatta, for
the reason that Rachenhalli
will not give a sufficient
or satisfactory supply with
regard to quality unless
the whole catchment of
36 sq miles is purchased
the cost of which has been
shown to be prohibitory

(2) Para 84 (3) — With regard to group it has been proved that Maligal valley, even with additional catchment of 4 sq. miles, is insufficient, unless 2⅓ times the run-off hitherto accepted is calculated on, and percolation and evaporation reduced to more than 30 per cent of what is actually known to be the case. —

~~That~~ The Maligal catchment cannot even be increased to the extent now proposed by Major Grant at a cost at all commensurate with the advantages to be derived therefrom, and ~~that~~ any further extension is most unadvisable. —

(3) Para 86. — With the catchment area of Bachenhalli heavily manured and the greater part of it under cultivation, it is inconsistent to assume that the water is as pure as that at Hesergholta, where manure is used most sparingly and much of the land is fallowing waste — Chemical analysis mentioned in para 27, cannot detect the existence of infectious matter in water but could this be done, and water taken from Bachenhalli in June and July were analysed the result would be [illegible]

Major Grant. —

Para 87. — Allowing the run-off hitherto accepted, a free catchment area entirely uncultivated of 36 sqr. miles is requisite to insure a reliable supply, and this cannot be had in the vicinity of Bangalore, except at a prohibitive cost, the only project at all within the means of both Station is the Hesserghattu one, and the reason for its being so, is the advantages it has above all others of not requiring an extensive or expensive catchment. —

(5) Para 87. — It is true that a population of 100,000 has existed on the water procured from the catchment area of upwards of 10 sqr. miles and from numerous wells, but it has been a most existence for the poorer classes, and so disastrous to life that a project based on this assumption is likely to meet with very scant favor. —

(6) Paras 88 to 90. — The great difference in cost between Lache Halli and Hesserghatta has been clearly explained

explained in paras 12-13-14 and 15 of this report, from which it will be seen that this is not due to neglect of sanitary measures for proper conservancy of water, or to cheapness of specification, as the Rachenhalli dam works out at Rs. 55,959 in excess, and 3 dams in Maligal valley at Rs. 123,000 in excess of amounts quoted by Major Grant, when calculated on the so frequently quoted "Hesserghatta data and specification."

(7) Para 91 — The abstract referred to here has been shewn to be seriously incorrect (vide para 35 of this report).

Bangalore
5th May 1898

Executive Engineer,
Bangalore Division.

Quote all in print Complete also Scaldwells.

To

The Resident in Mysore

Sir,

Adverting to the reports quoted in the margin ~~in~~ the various schemes which have been proposed for the joint supply of water to the City & Co & Mr State of Bangalore, I have the honor ~~to State that I have carefully studied them~~ to place before you the conclusions ~~at~~ to which, ~~I have arrived after a very careful study of them.~~ After very careful consideration, I have been able to arrive —

The Hebbal Scheme

2

A reservoir at Hebbal with a catchment of 14 sq. miles I have always regarded as utterly insufft. ~~for~~ even for the supply of the Petta alone, and the recent investigations which have been made only confirms me in that opinion. To add to the Hebbal supply that from Sankey's Reservoir ~~wd.~~ ~~[illegible]~~ in the way proposed by Major Grant will not in my opinion give appreciable better results. ~~From a suggestion~~ When Col Bowen was ~~I caused him to investi~~ here he investigated at my instance the feasibility of supplementing the supply in Sankey's Reservoir from catchment areas in the direction of Singanayakanhalli Tank. I ~~[illegible]~~ ordered this investigation from the suggestion of certain remarks I found in Col Sankey's original report on the ~~[illegible]~~ subject. A few ~~[illegible]~~ surveys & lines of levels were taken and they showed that such a mode of supplementing the supply in Sankey's wd. be excessively costly and otherwise unsatisfactory. It was after this that we went to Hessargatta as the ~~only~~ last locality which afforded the prospect of sufficient supply.

To add efficiently to Hebbal

Catchment areas of the Valleys as proposed, wd involve an expenditure several times the Seven Lacs which Major Grant Estimates as the probable Cost, and the result wd be more or less precarious - In the opinion of the Dunbar the Hebbal Scheme is altogether unsuitable and it is one which they wd not look upon with favor Even for the Separate Supply of the Pettah alone —

The Rachenkalli Scheme.

~~After Con~~

I am distinctly of opinion that the 15 Square Ms of the So called "free" Catchment of Rachenkalli, ~~will be utterly~~ Even with the addn of the Yelkanka Tank & 4 or 5 Sq. miles in its immediate Vicinity, will be utterly insufft for a joint supply. If the Entire "Outlying" Catchment of 21 Sq. miles be added to the "free" Catchment of 15 Square miles (by an Expenditure which is likely to be 2 or 3 times what major grant assumes), the Supply I fear wd still be found insufft in a Series of bad years. To provide for an assured supply in such years it ~~wd~~ will be necessary to add the Hebbal supply by means of a very costly channel, but the acquiring & depopulating ~~&~~ of the 50 Sq. miles of the Rachenkalli & Hebbal Valleys (for it must not be forgotten

that ~~then~~ practically there W^d. be depopulation,
as ~~for~~ no population can exist when the
net work of tanks on which they depend
~~for man & beast beast~~ is destroyed)
will be ~~such~~ such as to make
Rachenhalli impossible
as the source of ~~a~~ ~~f~~ a water
supply to Bangalore -

~~Maji~~

4 The Maligal Scheme ~~Sheme~~ After making every allowance for the admitted superiority of this Valley in the matter of run-off, I am of opinion the

Major Grant in his report of the 23d March assumes ~~in my opinion~~ an unduly high rate of run-off which ~~in this Valley~~ - The rate assumed in his first report is to my mind nearer the truth. ~~Mark truth; Every allowance~~ His conclusions drawn from ~~thereon he observed~~ "clear traces of a run off" ~~which he~~ observed in this Valley after a rainfall of only 15 cents one night at the Ulsoor ~~Rock~~ Rock are of no value ~~without in all probability than the fall in was in the Valley itself a fall over fully 1½ inch was over 1 inch~~ for we find the fall the same night in ~~the~~ Sankey's Catchment at the head of that Valley ~~the same night~~ was over 1 inch and the fall in the Valley itself was presumably a good deal more. ~~much more~~

not improvingly

Upon this subject Mr McHutchin's ~~experience~~ as stated at page 15 of his note of 10 May 1893 ~~agt Mr~~ (opposite paras 47 & 48 of Major Grant's report) and upon that of Mr Scaldwell in paras 20 & 21 of his note of 5 May 1893. After a very careful study

The 10 sq miles of direct catchment ~~in the Maligal Valley it is found will~~ will be insuffc. to fill the proposed 4 tanks even in an ordinary year. It is therefore absolutely necessary to ~~indent upon~~ make artificial addns to the catchment proper - These addns ~~will have~~ have to be very costly if they are to be at all efficient, and ~~when made the~~

of the offer
t is safer
rely on
~~upon~~ the
experience of

~~Consideration~~
of the details, the
nclusion I
ave arrived
at as regards
Maligal as a
joint scheme is
briefly as follows:

and if they are carried out without ~~[illegible]~~ regard to ~~[illegible]~~ the disproportionate cost, ~~[illegible]~~ required make them efficient the aggregate supply will still be found to fail except in years of good or average rainfall — ~~[illegible]~~

~~Subject I wd invite your Perusal of pp 17, 18, 19 & 20 of Mr McHutchin's report~~ — under such circs I have no doubt that Maligal is ~~utterly unsuited~~ quite unsuited for a joint supply —

It will be unwise ~~not to bear in mind~~ to forget the Element of risk which attaches to all ~~every one of~~ the 4 proposed Reservoirs from the very nature of their situation, ~~or~~ to avoid ~~and to incur~~ the extra expenditure required to make them as stable as possible. Altogether the entire cost of the scheme is not likely to be under 40 lacs, and for this large sum of money we are ~~not~~ likely to get ~~any thing but~~ ~~[illegible]~~ ~~at best~~ a System of supply ~~at best more~~ which is bound to be more or less precarious and dependent upon ~~Seven~~ Seven Reservoirs, ~~4~~ four in the Jame Valley & three in neighbouring Valleys.

Water Supply of Madras

7. The Hessarghatta Scheme This Scheme with some modifications suggested by Col. Du V. Campbell in his Supplemental Report of the 22nd March '93 is undoubtedly the best of all that have hitherto been proposed for a joint Supply. The Excavation across which the Hessarghatta Tank embankment partakes so much of the nature of a perennial Stream that, in exceptional years of Scanty Rainfall, it will not be necessary, even during the hot months actually to draw upon the Impounding Reservoir. For the Gauges established to which I had last Easter my visit to Hessarghatta in July last established to which I had last Easter my visit to Hessarghatta in July last established to which I had last Easter my visit to Hessarghatta in July last

also the Superiority of Hessarghatta to Hebbal, or Rachenhalli or Malagal has I believe been conclusively demonstrated by Col Campbell's, Mr McHutchin's & Mr Scaldwell's notes on Major Grant's report of the 23d ~~May~~ March 1893.

9. Next as regards the chemical purity of water, Hessarghatta is admittedly far superior to either Hebbal or Rachenhalli but may concede that it is inferior to that portion of the ~~Mag~~ Malagal & ~~Scheme which embraces~~ which is derived directly from the 10 Sq. Miles of its own proper Catchment - But there is as yet no evidence of this, for it is one thing to take a sample of water from ~~an impounding a~~ the terminal Reservoir at the end of a Valley (as was done in the case of Hessarghatta) and quite another to take one from little pools or tiny streams found at the bottom of the Valley after a shower of rain (as was only possible in the case of Malagal). With my knowledge of the sparse popn & scanty culture

on which so much stress has been laid

of the Cankavati Valley extending
up to the Kundidrug Range of Hills & the high lands
~~North of Doddabetta lands~~ towards
the Makalidrug ~~Range~~ Range, it would
surprise me very much to find
that the ~~impurity~~ quantity of impurity
due to human habitation, Cattle, &
Cultn. ~~was~~ was greater per Sq. Mile
of the 2 1/2 Sq. Miles draining into
Hesarghatta than it was per Sq. Mile
of the 20 Sq. Miles of drainage area
comprised in
the Madigal ~~Valley~~ Scheme (ie.
10 Sq. Mn. of the Madigal Valley, ~~&~~ 6 Sq. Mn. of
the Hebbal Valley & 4 Sq. Mn of the highly manured
~~Mathikere~~ Valley) — And if we admit
~~the fact that a certain quantity~~
~~of impurity is~~ that dilutation
makes "impurity" less unwholesome,
~~but, there is a~~ it is evident
Then Hesarghatta possesses this
advantage on a very large
Scale Whereas it wd be
practically absent as regards
the artificially added Catchment
of Madigal

Setting aside these considerations ~~are~~ for the moment we have also to bear in mind ~~that Chemical~~ the fact that it is easy to attach ~~to~~ the great an importance to the Chemical Analysis of water, ~~The best Chemists admit that It is an admitted fact~~ which admittedly is as yet unable to detect ~~in water~~ the real pathogenic elements ~~of~~ in water — If ~~it is con~~ nevertheless it ~~the~~ is considered proper to defer to the conclusions of Medico-Chemical Science as far as they go, ~~we~~ ~~to~~ we have first to submit to ~~Analysis~~ analysis water passed through an efficient filtering medium, such for instance as "Polarite", before we can attach any practical value to the results obtained, for an efficient filtering medium has always been assumed as

the Sine qua non of any Scheme
for the water Supply of Bangalore -

After proper filtration it is
very probable that there will be
found no appreciable difference
as far as the results
of Chemical analysis go
between the water
impounded in the Nagarbhavi
& Hesaraghatta
Reservoirs - In ordinary
prudence I think we shd be
satisfied at the present stage
of our knowledge with the
well known fact referred
to by Col Campbell that
the Arkavati Valley is
noted for its salubrity - &
the people residing in it
are never known to suffer
from any of the injurious
Effects of a bad water Supply -

11. After giving the whole Subject very attentive consideration the Durbar are opinion that the Hessarghatta scheme is the only one which offers the prospect of a successful joint water supply. They are so impressed with this conviction that they have no hesitation in rejecting Maligal, Hebbal & Rachenhalli as unsuited for the purpose of a joint scheme.

12 If under such circ^ces separate schemes for the City & Station have to be worked out, the Durbar, as at present advised, ~~tod~~

If further argument were required in ~~support~~ ~~in~~ favor of the Superiority of the Hessarghatta Scheme over all others that have been ~~prop~~ proposed, I wd beg leave to advert to a fact (which has recently come ~~within~~ to my ~~known~~ knowledge ~~by~~ through Col H M Vibart's letter ~~which~~ was published in the Madras Mail of the 5th Instant) that ~~the~~ a Scheme in many respects identical with the ~~one now proposed~~ present one had been proposed by that Officer five years ago. When I decided to go to Hessarghatta I was aware that Col Vibart had in a general way indicated the Arkavati Valley as the probable direction

in which & supply was to
be found, but I was not
aware that he had investigated
a Hessarghatta Scheme
as now I see he did from
the Extracts from his letters
of the 11th Novr 87 & 27
April 88 Extracts from
which are published in
the Madras Mail. I ~~have~~
tried to get copies of these
letters but have so far
been ~~un~~successful — I
believe also that neither
Col Campbell nor Mr
Scaldwell have seen these
letters for the former makes

and you informed me two days ago ~~lately~~
that after due search they ed
not be traced in your own office

only a passing allusion to
Col. V's proposal for a new dam
across the Arkavati and
the latter ~~quotes~~ refers only ~~from~~ to
~~& in the first~~ Col. V's letter of
20 Octr 87 which apparently
contained his first ideas
on the subject of utilizing
the Arkavati drainage
& not the more matured
proposals contained
in his two subsequent letters
above quoted. It is important
to note for our present case that
Col V. ~~reported~~ states in his letter of 11 Nov 87
referring to the Hersargutta tank that "The Chem. Exp
The water of this (bank?) tank is 'usable'"
It may be interesting to get this Chemical
analysis ~~as well as for the~~ as
also Col V's entire report for purpose
of reference - whether these papers
be readily forthcoming or not, the

the Hessarghatta Scheme was
proposed 5 yrs ago by Col V. is
~~proof~~ an instance of the proper
solution of a question suggesting
itself to several minds
independently ~~allow~~ investigating
it, ~~th~~ and as such an
argument in favor of Hessarghatta
~~agt. all~~ as compared with
the other Schemes -

will utilize an improved Hessarghatta Reservoir partly for Irrigation & partly for the Supply of the City. 13 If, on the other hand, it is finally decided that Hessarghatta Shd be ~~the~~ a Joint Scheme, then will arise for solution the question asked in Yr letter ~ Q04

as to ~~the adjustment of the Cost involved~~. Before proceeding to answer this question, I ~~wd~~ may state that the Durbar are not in a position to accept the Conditions proposed by Major Grant in para 101 of his Report

What for C. of the Public Service the Durbar will be prepared to Carry in C. [illegible] at Thing

14. As indicated in my note of the 18 Feby last, the Durbar will be willing to give to the two municipalities the water required at the Hessarghatta Reservoir for a ~~fixed~~ moderate price. The Durbar cannot conveniently undertake to lift & carry the water to the Service Sistern at Bangalore. This work can more conveniently be done ~~jointly~~ by the two municipalities. What I wd propose is thereof as follows:—

(a) The Durbar to ~~do~~ all work ~~that is~~ required for the proper storage of water at Hessarghatta at their own cost ~~and~~ to man the same in an efficient condition, ~~very from the 2 municipalities for such~~ and to ~~give~~ receive for the supply taken from the Reservoir, ~~for~~ a price to be calculated ~~required~~ ~~at a fixed moderate price~~ at a moderate rate to be ~~previously~~ now fixed permanently. But the Durbar not to be liable to pay ~~compensate~~

any damages or compensation for any diminution or interruption to the supply required, arising either from any accident to the works or from the failure of rains or from any other ~~unavoidable~~ causes whatsoever.

(B) The lifting & ~~delivery~~ carrying of water thus taken from the Storage Reservoir to the Service Cistern at Bangalore to be the joint work of the two municipalities both as regards construction & maintainance. The Engineers & other agents required ~~that~~ can be appointed by both municipalities jointly, ~~&~~ and on any Energy ~~they wd~~ there wd be available for their help the combined resources of the B. Govt & the Durbar. This is a far Taper arrangement than throwing upon the Durbar the entire responsibility for delivery at ~~B~~ the Service Cistern at Bangalore.

(C) The distribution ~~from~~ beyond the Service Cistern at Bangalore to be the separate work of each municipality, to be paid for & maintained by it.

and (D). The cost on acct. of price of water (A) and on acct of lifting & carrying (B) to be distributed between the two municipalities in some equitable manner upon the basis of the ~~water~~ quantity of water drawn ~~taken~~ by each from the service cistern at Bangalore with ~~due~~ regard, it is subject to the fact ~~that~~ that any of the extra lift is entailed ~~to the C~~ upon the city supply, by reason of the joint character of the supply. ~~and grant in aid to the grant in aid in money~~

No. 36. Proposed Draft

Issued

Office of the Dewan of Mysore
Dated Bangalore, 29th

To

The Resident in

Sir,

Adverting to the Reports quoted in the margin* on the various Schemes which have been proposed for the joint supply of water to the City and C. and M. Station of Bangalore I have the honour to place before you the Conclusions at which, after very careful Consideration, I have been able to arrive

2. A reservoir at Hebbal with a catchment of 14 sq miles, I have always regarded as utterly insufficient even for

1) Report on the Hessarghatta Project by Mr. R. J. Scaldwell, Executive Engineer of Bangalore of 10.1.93.
2) Preliminary Report on the same by Col. D McNeil Campbell, R.E., Chief Engineer of Mysore, of 26.1.93.
3) Note on the same by the Dewan of Mysore of 18.2.93
4) Supplemental Report on the same by Col. D McNeil Campbell, R.E., Chief Engineer of Mysore. of 22.1.93.
5) Report on the several Schemes (Hebbal, Nachenahalli, Hessarghatta and Malpal Valley) by Major S. Grant. of 23rd March 1893

The Hebbal Scheme

(6) Note on the above by Col. D McNeil Campbell, R.E., Chief Engineer of Mysore of 3.4.93
(7) Note on the same by Mr W. McHutchin, Offg Chief Engr. in Mysore of 10.5.93.

supply of the Tetta alone, and the re investigations which have been made only confirm me in that opinion. To add to Habbal supply that from the Sankey's reservoir in the way proposed by Major Grant, will not in my opinion give appreciably better results. When Colonel Bowen was here, he investigated at my instance the feasibility of supplementing the supply in Sankey's reservoir from catchment areas in the direction of Singanaikanahalli tank. I ordered this investigation from the suggestion of certain remarks I [illegible]

in Colonel Sankey's original report on the Subject. A few surveys and lines of levels were taken and they shewed that such a mode of supplementing the supply in Sankey's would be excessively costly and otherwise unsatisfactory. It was after this that we went to Hessar-gatta as the ~~last~~ best locality which — afforded the prospect of a sufficient supply.

To add efficiently to Habbal, Catchment areas of other valleys as proposed would involve an expende-

- ture Several
the Seven lakhs
which major Grant
estimates as the
probable Cost, and
the result would be
more or less precar-
rious. In the
opinion of the Dunbar,
the Hebbal Scheme
is altogether un-
suitable and it is
one which they
would not look
upon with favour
even for the separate
supply of the Pettah
alone.

The Rachenahalli Scheme.

8. 4 I am distinctly
of opinion that the
15 Sq. miles of the So-
called "free" Catchment
of Rachenahalli, Even
with the additi

the Yallahanka tank and 4 or 5 Sq. miles in its immediate vicinity, will be utterly insufficient for a joint supply. If the entire "outlying" Catchment of 21 Sq. miles be added to the "free" Catchment of 15 Square miles (by an Expenditure which is likely to be 2 or 3 times what Major Grant assumes), the supply, I fear, would still be found insufficient in a Series of bad years. To provide for an assured supply in such years, or in d

be necessary to add
the Hebbal Su
by means of a very
costly channel, but
the acquiring and
depopulating of the
50 Sq. miles of the
Rachenahalli and
Hebbal Valleys (for
it must not be
forgotten that —
practically there
would be depopu-
lation, for no —
population can
Exist when the net
work of tanks on
which they depend
is destroyed) will
be such as to make
Rachenahalli im-
possible as the source
of a water supply for
Bangalore.

The Malegal Scheme. 5. After making every allowance for the admitted superiority of this Valley in the matter of rum-ff I am of opinion that Major Grant in his report of the 23rd March assumes an unduly high rate of rum-ff The rate assumed in his first report is, to my mind, nearer the truth. His conclusions, drawn from "clear traces of a rum-ff" observed in this valley after a rain-fall of only 15 Cents one night at the Ulsoor Rock are of no value, for we find the fall the same night

Sankey's Catchment at the head of the ~~Malizal~~ V was over one inch the fall in the Valley ~~obs~~ itself was not improbably a good more. Upon this Subj of run-off, it is safer, rely on the experience of Mr. McHutchin s stated at page 15 of his note, dated 10th May 1893 (opposite paras 47 and 48 of Major Grant's report) and upon that of Mr. Scaldwell in paras 20 and 21 of his note dated 5th May 1893.

After a Very Careful Study of the details, the Conclusion I have [illegible]

regards Maligal as
a joint scheme is
briefly as follows:—

The 10 Sq. miles of
direct catchment
will be insufficient
to fill the proposed
4 tanks even in an
ordinary year. It is
therefore absolutely
necessary to make
artificial additions
to the Catchement—
proper. These addi-
tions have to be very
costly, if they are to
be at all Efficient
~~Cost~~ if they are carried
out without regard
to the disproportionate
cost required to make
them Efficient, the
aggregate outlay
will still be found
to fail [illegible]

years of food or
average rainfall.
It will be unwise to
forget the element of
risk which attaches
to all the four pro-
posed reservoirs
from the very nature
of their situation, and to
attempt to avoid the
extra expenditure
required to make
them as stable as
possible. Altogether
the entire cost of the
scheme is not likely
to be under 40 lakhs
and for this large sum
of money we are
likely to get a
system of supply
which is bound
to be more or less
precarious in

dependent upon seven reservoirs, four in the same Valley and three in the neighbouring valleys. Under such circumstances, I have no doubt that Malegal is quite unsuited for a joint supply.

The Hessarghatta Scheme. 7. This Scheme, with some modifications suggested by Col. Mc. Neil Campbell in his Supplemental Report of the 22nd March 1893, is undoubtedly the best of all that have hitherto been proposed for a joint supply. The Arkavati, across which the Hessarghatta is the terminal bund, partakes to a

of the nature of a
perennial Stream
that except in ex-
ceptional years of
scanty rainfall, it
will not be necessary
even during the hot
months, actually to
draw upon the supply
in the Impounding
Reservoir. The flow
Established after a
visit to Hessarghatt
in February last
shows the daily flow
into the reservoir
during the hot months
to have been 600,000
C. ft Whereas we
only want 400,000
per day for the —

supply of a population of 200,000. The 212 sq. miles of drainage area in the Same Valley makes the Hessargatta much more reliable as a source of supply than any other which involves the artificial addition of the drainage of other Valleys.

In regard to cost also the superiority of Hessargatta to either Habbal or Rachenahalli or Maligal has, I believe, been conclusively demonstrated by Col. Campbell's, Mr. McHutchins and Mr Sealdwells

Notes on Major Grant's
Report of the 23rd March
1893.

Next as regards
the Chemical purity
of water on which so
much Stress has been
laid, Hessaraghatta
admittedly far supe
rior to either Hebbal
or Nachenahalli. We
may concede that it
is inferior to Maligai
if we take into ac——
account only that
portion of the Maligai supply
which is derived
directly from the 10
Square miles of its own
proper Catchment. Thus
there is as yet no
evidence of this, for
it is one thing

take a sample of water from the terminal reservoir at the lower end of a Valley (as was done in the Case of Hessar-Gatta) and quite another to take on from little pools or tiny streams found at the betto of the Valley after a shower of rain (as was only possible in the Case of Maligal). With my knowledge of the sparse population and scanty cultivation of the Arkavati Valley extending up to the Nandidroog

range of hills and the high lands towards the Makalidroog range, it would surprise me very much to find that the quantity of impurity ~~to~~ due to human habitations, Cattle and Cultivation was greater per Sq. mile of the 212 Square miles draining into Hessarghatta than it was per Square mile of the 20 Square miles of drainage area comprised in the Malagal Scheme (i.e. 10 Square miles of the Malagal Valley, 6 Sq. miles of the Hebbal

and 4 sq miles of
the highly manured
Malathalli Valley).
And if we admit
that dilutation makes
"impurity" less unwhole-
-some, then Hessarg
possesses this adv
on a very large scale,
whereas it would be
practically absent
as regards the arti-
ficially added catch-
-ment of Maligal
Setting aside these
considerations for
the moment, we have
also to bear in mind
the fact that it is easy
to attach too great
an importance
to the [illegible]

Chemical analysis of
~~water~~ which admit-
-tedly is as yet
unable to detect the
real pathogenic
Elements in Water.
If nevertheless it is
Considered proper
to defer to the Con
Clusions of Medico-
Chemical Science
as far as they go,
we have first to
submit to analysis
Water passed
an Efficient filtering
medium, such for
instance as
"Polarite", before I
Can attach any
practical Value
to the results
obtained, for an
Efficient filtering
medium

medium has always been assumed as the *sine quâ non* of every scheme for the water supply of Bangalore. After proper filtration, it is very probable that there will be found no appreciable differences, as far as the results of Chemical analysis go, between the impounded in the Nagarbhavi and Hesarghatta Reservoirs. In ordinary prudence I think we should be satisfied at the present stage of our knowledge with the [illegible]

refeared to by Col. Camp-
-bell that the Arkavati
Valley is noted for its
Salubrity and the
people residing in it
are never known to
suffer from any of the
injurious Effects of
a bad water supply

10 If further argu-
-ment were required
in favour of the Sup-
-ity of the Hessargatta
Scheme over all other
that have been pro-
posed, I would beg
leave to advert to a
fact (which has re-
cently come to my know-
-ledge through Col. H.M
Vibart's letter, publish-
-ed in the Madras
mail of the 5th instant
that a Scheme in some
respects identical
with the present one
had been proposed
by that Officer for

years ago. When
decided to go to Hesar
-gatta, I was aware
that Colonel Vibart
had in a general
way indicated the
Arkavati Valley as
the probable direction
in which a supply
was to be found, but
I was not aware that
he had investigated
a Hesargatta scheme
as now I see he did
from the Extracts from
his letters of the 11th
November 1887 and
29th April 1888,
extracts from which
are published in
the Madras Mail.
I tried to get Copies
of these letters but
have not yet succeeded

been successful and
you informed me
~~Lately~~ Last Wednesday that after due
search they could
not be traced in
own Office. I believe
also that neither
Colonel Campbell
nor Mr. Sealde
have seen these
letters, for the
makes only a passing
allusion to Colonel
Vibart's proposal
for a new dam across
the Arkavati and
this latter ~~only~~ refers only
to Colonel Vibart's
letter of 20th October
1887 which apparently
contained his first
ideas on the desirability
of utilizing the

Arkavati drainage
and not the more
matured proposals
contained in his two
subsequent letters
above quoted. It is
important to note
for our present
case that Colonel
Vibart states in his
letter of 27th April 1888 ~~11th November~~
~~1887~~, referring to the
Hessarghatta Tank, that
"The Chemical Exami-
ner reports that the water
of this (bank?) tank
is 'usable'". It may
be interesting to
get this chemical
analysis as also
Colonel Vibart's
entire report for
purpose of reference.
~~Whether~~ - ~~[illegible]~~

After obtaining these papers it may probably be necessary for me to submit a few additional observations. But, for the present, I would remark that the fact ~~be readily for the~~ ~~or not~~, that the Hessian fatta Scheme was proposed 5 years ago by Colonel Vibart is an instance of the proper Solution of a question ——— suggesting itself to several minds independently investigating it, and as such, an Argument in favour of Hessian-fatta as Compared with the other Scheme.

After giving the whole Subject very attentive Consideration the Durban are of opinion that the Hessian-fatta Scheme is the only one which offers the [illegible]

successful joint water-supply. They are so impressed with this conviction that they have no hesitation in rejecting Maligal, Hebbal and Rachena-halli as unsuited for the purpose of a joint Scheme.

12. If under such circumstances, Sepa-rate Schemes for the City and Station have to be worked out, the Dunbar as at present advised, will utilize an im-proved Hesarghatta Reservoir partly for Irrigation and partly for the Supply of the City.

If on the other hand it is definitely decided that Hesar-ghatta should be a joint [illegible]

arise for solution the question asked in your letter No. $\frac{4}{28\ 88}$, dated Camp Ootacamund 27th April 1893, as to what part of the Entire Scheme the Durbar will be prepared to carry out and maintain at their own risk and expense.

14 As indicated in my note of the 18th February last, the Durbar will be willing to give at the Hessarghatta Reservoir to the two municipalities the water required for a moderate price The Durbar [illegible]

[illegible]

Conveniently, under-
take to lift and
Carry the water to the
Service Cistern at
Bangalore. This work
Can more Conveni-
ently be done by the two
Municipalities as
a joint Stock affair.
15 What I would
propose is therefore
as follows: —
(A). The Durbar
to do all work re-
quired for the proper
Storage of water at
Hessaraghatta at their
own Cost ~~and~~ to
maintain the Same

an Efficient Condition
and to receive for the
supply taken from
the Reservoir a price
to be calculated at
a moderate rate
to be now fixed
permanently. but
the Dunbar not to
be liable to any
damages or Compen-
sation for any dimi-
nution in or inter-
ruption to the supply
required, arising
either from any
accident to the works
or from the failure
of rains or from any
other Cause [illegible]

(2) The lifting and
carrying of water
thus taken from the
Storage Reservoir
to the [illegible]

at Bangalore to be the joint work of the two Municipalities both as regards Construction and maintenance. The Engineers and other Agents required can be appointed by both Municipalities jointly, and on any emergency there would be funds available for their help the Combined resources of the British Government and the Durbar. This is a far safer arrangement than throwing upon the Durbar the entire responsibility for delivering to the

Service Cistern at Bangalore.

(c) The distribution beyond the Service Cistern at Bangalore to be the separate work of each Municipality, to be executed, paid for and maintained by it.

~~and~~ (d) The Cost on account of price of water (a) and on account of lifting and carrying (b) to be distributed between the two Municipalities in some equitable manner upon the basis of the quantity of water drawn by each from the Service Cistern at

Bangalore, with due regard, it is submitted, to the fact an extra lift is entailed upon City supply, solely by reason of the Character of the Scheme

and (E) Should there happen a reduced supply of the service cistern from any cause whatsoever then the available supply to be distributed between the two Municipalities in the proportion of their respective populations

Camps No 304 dated 20th May 1893

Copy forwarded, together with copy of letter No 4-78-50 of 27th April 89. from the Resident in Mysore, forwarded to the Secretary to the Government [illegible]

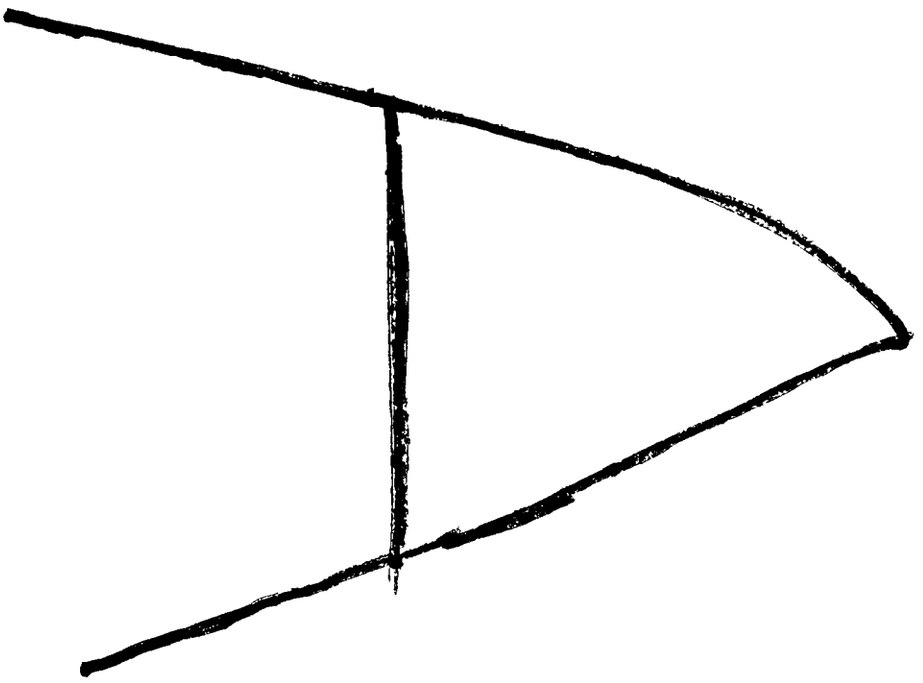
MYSORE P. W. DEPT.

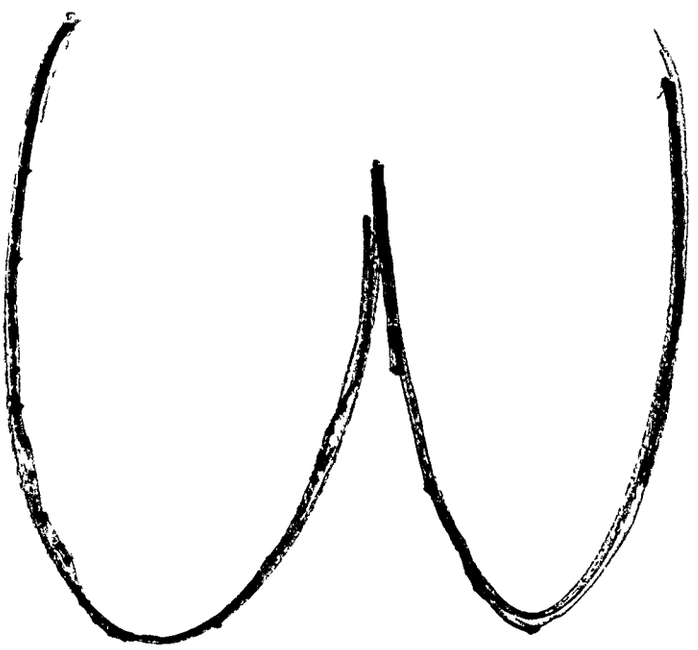
TO THE DEWAN OF MYSORE

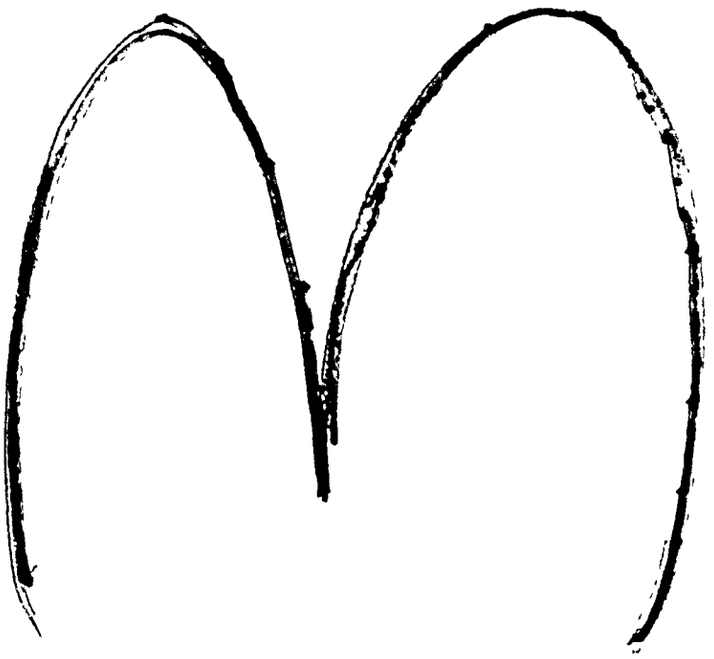
for Information.

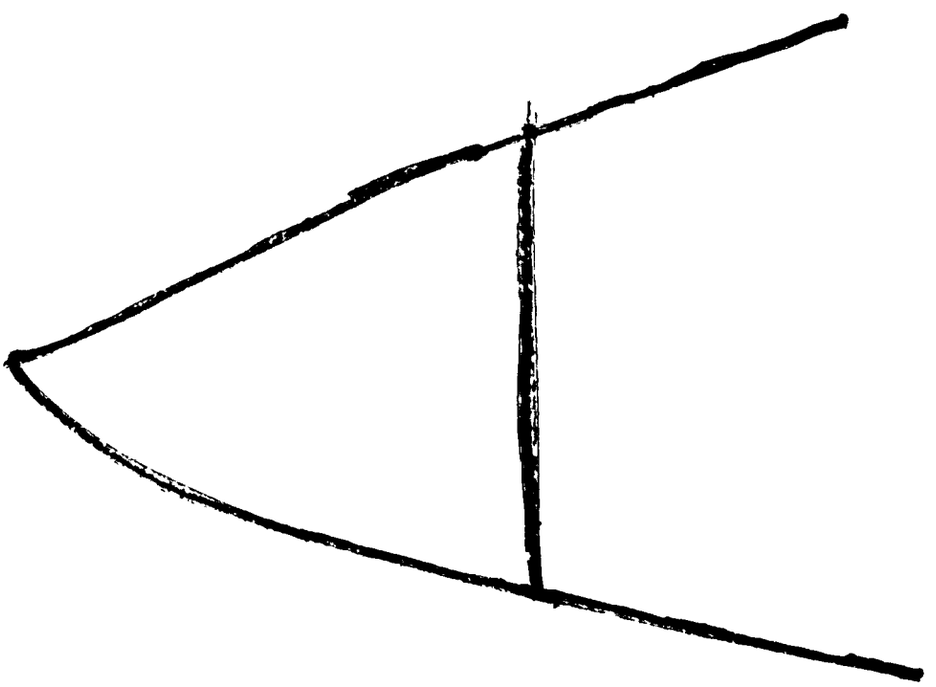
In continuation of this office note of the 1st instant, and with reference to the concluding para of your note dated 15th April 1873, I submit copy of a statement prepared by the Ex. Engr. Bangalore Div., showing the water spread and irrigable area of the Jadi Tank Devarkhondapur, and of all Tanks draining into it. I am this day sending a copy of the statement to Colonel Grant, in compliance with your orders in note quoted above.

II Mr. Pedlowitz explains with regard to irrigable areas given in statements A and D of report on Hassergatha water supply [illegible] that the same are [illegible] from statements [illegible] [illegible] Dy. Pond.









D. P. W.

Memo

The actual occupied area under the 12 tanks comprised in the Hevargatta Water Supply Scheme is returned as follows

Name of Tank	Acres Wet	Acres Garden	Acres Total	Total Revenue
Hevargatta	202 27	110·19	313·6	1844-4
Byatra	75·18	10·17	85·35	574
Ka Kal	123·33	11·20	135·13	842-4
Sonnenahalli	44·9	1·36	46·5	235
Chikdevarpur	27·37	2·13	30·10	162
Jembankeré	Not Stated			
Devarkunte	25·6	6·24	31·30	124
Arsikunte	19 29	1·29	21·18	84
Shambhopanhalli Bindemanhalli Anikeré Yattikeré	Not Stated.			
Total	518·39	144·38	663·37	3865-8

The Deputy Commissioner will submit in Consultation with the Executive

Engineer at a very early date a Statement of the Compensation required for the whole of the occupied lands irrigated by the 12 tanks in question. The Statement should show separately such of the above mentioned lands as are likely to be submerged by the proposed enlargement of Hesarghatta and their value.

When I was last at Hesarghatta, I was assured by the Assistant Commissioner in attendance that orders have already been issued prohibiting the permanent grant of occupancy rights in lands likely to be required for the

the work in question. I hope these orders are being duly carried out.

As regards garden lands under the Hesaraghatta tank, the occupants are probably willing to keep them on the ground that the percolation from the tank is sufficient for them and that they need no direct irrigation. This point should be investigated. Whatever be the result of this investigation, compensation on their account should be separately included in the statement to be submitted.

Village and dry lands which have to be acquired on the ground

of possible Submersion —

(Villages situated within 10' or 15' of the proposed W. W. level and dry lands within 5' or 8' as the Chief Engineer may decide) — should be separately assessed. The Villages removed should be built outside the Catchment of Hesargatta and Aivarkhandpur tanks.

Mr B. G. Krishnaiengar, Sub Dn Officer on Special Dts ~~Assistant Commissioner~~, should be deputed to investigate the claims for Compensation and to settle them on fair and reasonable rates, with such instructions as the Deputy Commissioner

may

the land submergen 15' of prese level [illegible]

21/4

may Consider necessary.
No actual payments should be made before the Government pass orders upon the Statements now called for.

15th April 1893.

[illegible]

Vide [illegible] 121 [illegible] 15-4-93.

No. 1597/253 of 19/4/93.
Copy to the Exec: Engr. Bangalore Dn for information.

[illegible]

Received in [illegible]
[illegible]
21/4

[illegible]: Secretary
18/4/93

MYSORE P. W. DEPT.

TO THE DEWAN OF MYSORE

for Orders.

In your Memorandum No. 119 / P.H.O. dated Mysore 15th April 1893, you asked the Superintendent Revenue Survey to verify the Statements of "areas of waterspread," and Irrigable areas of the 12 tanks comprised in the Hessaragatta Water-Supply Scheme.—

Colonel Grant with his No. 1074 dated 26th April 1893, has sent the Revised Statements which I herewith put up together with a Note by him on the subject.

2.— The Statements for the Jodi Aivarkandpur Tanks will be sent as soon as received.—

3.— In another memo: (herewith put up) to the Deputy Commissioner the question of Compensation is entered into. It is simple enough to fix the amount of Compensation we are to pay

(1) For the tanks.

(2) For the irrigable area under them.

(3) For the area submerged, but we have to decide on the extent of the catchment which it will be considered necessary to throw out of dry cultivation, and what villages we are to remove?

Personally I do not consider it necessary to throw out of cultivation a larger area draining into the tank than comprised within about ½ a mile, from the margin of the waterspread of the Hessaragatta tank itself and all villages within that area should be removed

to

to new sites further

As regards the
and Kakol villages,
question is, rather,
are to be allowed to use
Kakol and Byata tanks
the source of their water
I personally do not think
that the contamination
from these 900 people
and their cattle would ap-
preciably affect the purity
of the 880 M cft of water we
are impounding, but in
bad years when the supply
is deficient they will of course
water their cattle &c and
obtain their supply from
Nessaragatta tank unless
they were removed elsewhere
and then the contamination
would be appreciable! It
will probably be necessary
to remove these villages
and stop wet cultivation
and manuring above the

Kakol

Kakol and Kyala tanks as well within a reasonable distance of their waterspreads, and this will be thrown out of cultivation probably by the mere fact of the removal of the villages themselves to below the Hessaragatta tank.—

Cattle grazing within 1/4 a mile of the waterspread of the impounding reservoirs I see no harm in, if this is fenced off in some way to prevent cattle going down to the tanks to drink.—

4.— Your other Memo: on the enlargement of the Hessaragatta tank, and proposing the addition of the Aivarkandpur catch=ment, and further investiga=tion of site for weirs &ca., has been referred to

Mr

Mr. Scaldwell
take this
detail as soon
finished with
Report.—

W. J. W. Hutchins

Offg: Secretary to the,
Mysore P.

Bangalore
1st May 1893.

No: 3031

Executive Engineer's Office
Bangalore Division
Bangalore 6th July 1893

To,

The Chief Engineer
of Mysore

Sir,

In reply to your no: 2874 of the 4th instant, forwarding memo by the Dewan of Mysore on the Hesserghatta Scheme for the Water Supply of Bangalore, I have the honor to inform you that I had surveys and leds in connection with the enlargement of the Hesserghatta tank prepared some time ago, but regret to say that some further information is requisite before even an approximate estimate can be framed of cost of such enlargement. —

2. — I have put further surveys in hand, and hope to be able to inspect the Arkavathy Kandpur valley shortly, and to submit the information called for with regard to enlargement of Hesserghatta tank before the end of current month. —

3. — I would here beg to bring to notice that the present establishment of the Division is quite inadequate for the transaction of

of the ordinary duties of the Division, and to allow of the preparation of a reliable estimate and satisfactory investigation of the several matters referred to by the Dewan of Mysore, a competent Assistant Engineer is absolutely necessary, and I would request that a special hand may be posted to the Division for employment on such work. —

I have the honor to be,
Sir,
Your most obedient Servant,

Scaldwell

Executive Engineer
Bangalore Division

Submitted to the Dewan, for information with reference to para 4 of his note of 1st Inst, extract enclosed. —

II. I have just sanctioned the employment of a temporary hand, (who was previously engaged in the surveys in connection with this scheme) - to assist Mr Scaldwell until Mr Inman's arrival, when Hony: Asstt. Engineer Mr Arnachallam Moodr. now in charge of French Rocks Division, will be posted to Bangalore Division, to assist in the preparation of the Hessergatta project and for execution of work. —

D. M. N. Campbell
Secretary to the Govt of Mysore P.W.D.

Bangalore
10 July 1893

The Printed Correspondence connected with the Hessergatta Scheme for the Water Supply of Bangalore.

× × ×

× × ×

× × ×

(4) When can I expect the information I asked for in regard to the enlargement of Hessergnatta? Have levels been taken about Aivarkandpur Tank? Has a better site for the waste Weir of an enlarged Hessargatta been selected? When may the project be expected to be ready.—

1/7/93

(Sd) K S
Dewan of Mysore.

I have replied
to this copy of
this shd. be cond
to DPW for in fn

MYSORE P. W. DEPT.

TO THE DEWAN OF MYSORE

for Orders.

With reference to the suggestion that the Sankey cum Hebbal Scheme should be adopted for the supply of the Pettah of Bangalore instead of the Hasserghatta, I have the honor to remark that it seems unnecessary to go into details which will take months to work out, as it can easily be shewn by general figures which of the two projects is the better.—

There can be no doubt that the Sankey cum Hebbal Scheme would be cheaper than the Hesserghatta,* the saving on piping delivery channel and pumps would

I always held that Hebbal cum Sankey wd. be insufft. for the Pettah. Col Campbell's opinion only confirms my upon this point. I merely asked the question with refce. to certain remarks from Mr Henderson.

The Hessarghatta scheme may go on. When may I expect it?

14-11-93.

Submitted to the Dewan.

In reply to the above enquiry I beg to report that the Hasserghatta Water Supply Scheme may be expected about two months hence.

[illegible] Campbell Secretary.
Secy. to Govt. of Mysore P.W.D.
24/11/93

* unless Sankey's tank has to be bought

Camp Lullock
21st November
1893

amount
Rupees, and this it is thought will more than cover the extra cost of buying the Hebbal tank and the 9 tanks above it. There would also be a saving on the working expenses as regards cost of fuel, but it is doubtful if this would not be more than covered by the extra loss of revenue under the tanks taken up. —

The question that has to be chiefly considered is the supply available.

The gross drainage area of Hebbal tank is 4½ Square Miles and of the Sankey's tank 2½, making a total of 7 Square Miles. —

In the Hasserghatta Scheme the run off calculated on is 315 M. cft. in a bad year of 17" rainfall, 12·2 M. cft. in an average year of 35" and from Hebbal & Sankey the run off, in a bad year would be 22·05 M. cft.

the supply required for the [illegible] as allowed in the Hasserghatta Scheme being 2 cft. for 125,000 people or 91·25 M. cft.

In an average year, the run off would be — 85·4.

It is therefore evident that the supply is not sufficient and the catchment would have to be increased by adding the 9 tanks above Hebbal, the total drainage area would then be Hebbal 14 Sqr. Ins.

Sankey — 2½ ..

Total 16½ ..

and the run off in the worst year would be — 51·975 cft. and in the best 201·30 M. cft., and even this is insufficient allowing for evaporation and percolation. It has been shown that in the Hasser=ghatta Scheme the supply is sufficient to last over three bad years of 17" rain=fall. I will now show that this is not the case at Hebbur the evaporation and percolation

being assumed to be the same
in each case.

The quantity required
for water supply for
3 years is 91.25 × 3 = 273.75 Mc.ft.
Evaporation in 3 years = 508.049
Percolation — " — 98.919
880.708

Deduct quantity received
in 3 years of 17"
rain fall 51.975 × 3 = 155.925

Storage required ——— 724.783 Mc.ft.

that means that in order to take over
3 bad years of 17" rain fall,
the tank should store 724.783 Mc.ft.
the present capacity of the Hebbal
tank is only 40.5 Mc. ft.
against 89.556 the capacity
of the Hasserghatta.

But the chief question is
where is this supply of 724.783
Mc. ft. to come from.
The greatest run off known on
the Sankey's catchment was
17 Mc. ft. per square mile, and
with this amount the run off
from the 16.5 sq. miles of Sankeys
and Hebbal would be
280.5 Mc. ft. it is thus evident-

max the run off would have to be almost 3 times the greatest known in order to obtain a sufficient supply to last through 3 bad years.

The case of Nasserghatta is quite different as the surplus of the upper tanks is received and the supply in an average year (not an exceptionally good one) is no less than 1367.72 Mb. cft.

I will now calculate taking the 3 worst years on record

1875 — 22"
1876 — 17"
1877 — 39"

Quantity required for
3 years supply — 273.75
Evaporation — 508.049
Percolation — 98.919
880.708

Quantity received 1st year — 84.80
2d " — 51.97
3d " — 238.14
374.91

Quantity required to be stored — 506.518

or double the run off in the best year.

The evaporation has been taken to be the same in both Schemes as it is impossible to ascertain what it would be in the case of the Sankey and Hebbal tanks, but it is probable that it would be greater than in the case of the Hasserghatta, as there is no ~~tank~~ tail water from tanks above to make up for the loss: but even taking evaporation and absorption in the Sankey and Hebbal Schemes to be half that in the Hasserghatta, it would still require the run off of the best years on record to obtain the supply required to last over 3 years of 22·17 and 39" of rain.

I hope I have said enough to show that the Hebbal cum Sankey Scheme will not give a certain supply to the Pettah and that it will be unnecessary to go into the question in detail.—

[illegible] Campbell Lt Colonel, R.E.,
Secretary to the Govt of Mysore P. W. Deptt
Bangalore 11th November 1893.

MYSORE P. W. DEPT.

TO THE DEWAN OF MYSORE.

for ~~Information~~. orders

I request that the Estimate for the Hessarghalla may be returned sanctioned as soon as possible, so the tenders can be invited. The work was started on petty contract so that the exact rates could be ascertained, and now as this has been done it is desirable that the work should be carried out by regular contract with proper bonds, and this cannot be done till the Estimate is sanctioned.

Peter Campbell Lieut Col
Secretary to the Govt
of Mysore

Camp Hiriyur
24th November
1893